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A critique of NAVSTAR global positioning system, user euqipment, configuration control for DoD common and Navy unique items

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A CRITIQUE OF NAVSTAR GLOBAL POSITIONING
SYSTEM, USER EQUIPMENT, CONFIGURATION
CONTROL FOR DOD COMMON AND NAVY
UNIQUE ITEMS

by

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and
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June 1983

Thesis Advisor: William H. Cullin

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June 1983

ABSTRACT

The User Equipment (UE) Global Positioning System (GPS) Configuration Control structures, procedures and information system up to March 1983 is critiqued. Our objective was to explore the existing configuration management plans in terms of documentation, with specific emphasis on the feasibility of the configuration control plans for the Navy unique and DoD common items. Our conclusion is that the GPS Configuration Control Structure is fundamentally sound. However, a major problem of integrating the various facets of configuration control management exists. To correct this deficiency, the GPS Program must now obtain interservice and intraservice written agreements of Configuration Control Responsibility to further specify and clarify each service's Configuration Control boundaries.

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I. INTRODUCTION

A. BACKGROUND

There is general agreement that military users would benefit from global deployment of a precise navigation system. Precise positioning and navigation (POS/NAV) needs for the Department of Defense (DOD) have traditionally been satisfied by a multitude of specialized equipments responsible to particular mission requirements. The result has been a proliferation of POS/NAV systems producing an aggregate of system facilities and airborne, shipboard, and ground user terminals with varying degrees of accuracy and capabilities. Deployment of the Global Positioning System (GPS) will reverse this trend while providing accurate POS/NAV for all military users.

Generally speaking, the conduct of military operations requires that forces involved accurately know their position, velocity, and time. The missions assigned to the respective services generate a broad spectrum of unique yet in many cases, similar navigation requirements. The degree to which these requirements are satisfied directly affects the outcome of military ventures, particularly in multi-unit and joint service operations.

Global navigation requirements as stated by the Assistant Secretary of Defense For Communications, Command, Control, and Intelligence are:

> We need a system which can provide accurate navigation anywhere on the globe, one which is independent of ground stations, since we cannot be assured of the cooperation of countries enroute or in the vicinity of a crisis. We need a system which is accurate enough to serve as an instrument landing system, since we cannot be certain of the facilities which will be available at the airfields in a given crisis area. We need a system in which security is inherent in the design and does not compromise the existence or position of the user. [Ref. 1]

The NAVSTAR GPS is a space-based radio positioning and navigation system that will provide extremely accurate three-dimensional position (to within 16 meters spherical error of probability), velocity (to within 0.05 meters/second) and system time (to within 55 nanoseconds) to suitably equipped users anywhere on or near (within 500 miles) the earth. The GPS consists of three major segments: Space System Segment, Control System Segment, and User System Segment. [Ref. 2]

The operational GPS Space System Segment deploys six planes of satellites containing three satellites each. this deployment will provide adequate satellite coverage for continuous and worldwide three dimensional positioning, navigation and velocity determination. Each satellite transmits a composite signal at two L-band frequencies consisting of a precision navigational signal (P CODE) and a coarse acquisition (C/A CODE) navigational signal. [Ref. 3]

The Control System Segment consists of four widely separated Monitor Stations that are located in U. S. territory or U. S. controlled territory. The stations passively track all satellites in view, and accumulate ranging data from the navigational signals. Ranging information is processed at a Master Control Station, located in the Continental United States, for use in satellite orbit determination and systematic error correction.

The User Equipment Segment consists of three user sets that will be used in numerous host vehicles. The thesis is focused on this segment.

Using the navigation signals from each of four satellites, the user receiver/processor (RPU) converts the pseudoranges and pseudorange rates to three-dimensional position and velocity, and system time. The position solution is in earth-centered coordinates, which can be converted to any coordinate frame or units of measure the

user requires. To accomplish the navigation function, pseudorange and delta pseudorange measurements are used to update a running estimate of the user's position. [Ref. 4]

B. ACQUISITION APPROACH

The acquisition approach for the GPS, recommended by the Defense Systems Acquisition Review Council (DSARC), is a step-wise, design-to-cost development and test program leading in successive phases to an operational GPS. Each phase is designed to build and expand on the previous phase in an integrated and cohesive manner. Phase 1, Concept Development, concentrated on validation of design concepts and developing a functional baseline through Development Test and Evaluation (DT&E) of user equipment. Phase 2, Demonstration/ Validation, will complete the DT&E and Initial Operational Test and Evaluation (IOT&E) of user equipment. Finally during Phase 3, Production/Development, the full GPS capability will be achieved. [Ref. 5]

Phase 1 encompassed the first of two design-build-test-design cycles to determine preferred user equipment configurations and validate the conceptual life cycle cost models in the design-to-cost process. The purpose of this approach was to reduce overall program risk, to reduce projected user equipment design and life-cycle costs through encouraging innovative designs, to increase industry competition by broadening the industrial base, and to fully investigate the potential classes of user equipment. Strong emphasis was placed early in these contracts on low development costs through the use of modular hardware and software designs, while total life cycle costs were minimized through the use of common modules across various host vehicle categories, wherever possible. [Ref. 6]

User equipment activities in Phase 2 are primarly concerned with development and testing of prototypes of user equipment. Two contractors are developing the basic set architecture for a family of user equipment hardware to be used in all classes of host vehicles. This approach provides commonality across all classes of user equipment designed by each contractor and should achieve the desired cost benefits in Phase 3. The commonality designed into the user equipment covers both areas of hardware and software.

During Phase 3, the user equipment will move into full scale production. The family of user equipments which best meets the user's needs in terms of performance and life-cycle-cost will be selected for production.

The user equipments to be produced, as determined by individual user requirements, will be procured in large lot buys. Eventually, 20-30,000 sets could be deployed by the U.S. Military with a like number deployed by our allies. [Ref. 7]

In summary, the three phased development and deployment of the NAVSTAR GPS is an evolutionary process. Each step provides extensive legacy value for the next step. Throughout this process, system level testing will be accomplished in order to insure optimum system operation and emphasis will continue to be placed on obtaining information on the utilization of all types of user equipment for new military applications and tactics.

C. PURPOSE/TIME FRAME OF THE RESEARCH

The objective of this thesis project is to explore the existing configuration management planning in terms of documentation, with specific emphasis on the feasibility of the configuration control plans for the Navy unique items and the DoD common items. A review of existing DoD, Navy and

Air Force instructions and directives was undertaken for a comparison base to evaluate the GPS configuration control management plans. A further study of existing literature on the subject of configuration control of both hardware and software, in conjunction with visits to the Joint Program Office (JPO) in Los Angeles, Ca. and Warner Robins Air Logistics Center (WR-ALC) in Warner Robins, Ga. completed our research.

The research was conducted during the September 1982 to March 1983 time frame. The GPS program was in full scale development and preparing for DSARC III. Our intention is to present a critique of the configuration control management plans as they existed during the research time frame. Our interpretations of the documents, including our understanding of the statements and comments gathered through interviews and telephone conversations, are the basis for the conclusions presented in this thesis. The acquisition and configuration management plans are dynamic; therefore, the analysis and conclusions are the result of the configuration control management plans as seen by the researchers, up to the March 1983 time frame.

D. ASSUMPTIONS

A basic assumption concerning the configuration control management of the GPS User Equipment (UE) should be noted. The assumption is the determination of which configuration items (CIs) and computer program configuration items (CPCIs) are DoD common or Navy unique. The Navy unique items for this discussion are considered to be the Flexible Modular Interface (FMI) and its associated CPCIs. Antennas could fall into the Navy unique category under certain conditions. This thesis was limited to the discussion of the FMI and its computer programs as the pivotal unique item. It was

considered by the researchers that if the configuration control management plans could support the FMI it would also be able to support any antennas associated with the GPS UE program.

The DoD common items considered in this project were the Control Display Unit (CDU), some antennas and antenna electronics and the Receiver/ Processor Unit (RPU). The RPU became the area of most concern due to its being the CI with embedded CPCIs and the unit that directly interfaces with the FMI. The RPU is in very simple terms a micro-computer consisting of approximately 80% software. The RPU in operational form has the software etched on computer chips making it firmware.

The user equipment segment of the GPS is composed of uniquely configured ensembles of equipment, called Sets, as well as test instrumentation and Peculiar Support Equipment (PSE). Each set consists of the hardware and software necessary to convert the GPS navigation signals into timing data, positioning data, navigation data, and control/display signals, as required. The scope of this thesis project is limited to and focused on the configuration control management plans for the Sets.

The remainder of this thesis deals exclusively with the user equipment segment. It is limited to the configuration control plans for the Navy unique and the DoD common user equipment.

II. CONFIGURATION CONTROL LITERARY RESEARCH

A. CONFIGURATION MANAGEMENT/CONFIGURATION CONTROL

Configuration Management (CM) accepts the fact that changes occur during a project's life cycle. Configuration Management tries to manage these changes and accept only the changes that offer a significant benefit to the government.

As a project moves through concept exploration, demonstration and validation, full scale development then into production and deployment (phases 0,1,2 and 3) its configuration identification is continually modified. Accordingly the configuration of a product is developed during concept exploration, determined during demonstration and validation, established during full scale development and maintained during production and deployment. [Ref. 8]

In a buyer-seller relationship, particularly in the aerospace marketplace where the buyer is usually purchasing not only the end product but its design and development as well, the point of departure or "baseline" between each phase has significance. Each baseline represents a point of decision by the buyer or negotiation between the buyer and seller, or both. The buyer must have some measure of supervision over the seller's activities to assure that ; (A) he has significant basis for making the basic critical decisions, such as continuation, cancellation or modification of a project; (B) He is getting the product contracted for at all times; and (C) The product will be compatible with the other configuration items in his complement of equipment or associated project interfaces. [Ref. 9]

The overall objective of configuration management is to deliver to the buyer, both functionally and physically, the intended product as specified by the contract drawings and specifications. The product configuration is identified to the lowest level to assure consistent performance, quality and reliability.

Configuration management allows for the integrity and continuity of technical and cost decisions related to the product's producibility, performance, operation and maintainance are recorded and controlled by Project Managers. The process of configuration management encompasses the specialties of configuration control, configuration identification and configuration accounting.

The goal of these operations is to assure that the delivered CI or CPCI meets Form, Fit and Function requirements. Configuration refers to a complete description of the physical and functional characteristics of a product. Configuration also applies to technical descriptions required to build, test, operate and repair a CI/CPCI. [Ref. 10] The major facets of configuration management are shown in Fig. 2.1.

Configuration Control involves the systematic evaluation, coordination and approval or disapproval of proposed changes to the design and construction of a CI/CPCI whose configuration has been formally approved internally by the company or by the buyer or both. [Ref. 11]

Configuration Identification refers to the technical identification that identifies and describes the approved product configuration throughout the design, development, test and production tasks. It also applies to the identification of changes and to product markings.

Configuration Accounting is the recording and reporting of CI/CPCI descriptions and all departures planned or made from the CI/CPCI through the comparisons of authorized

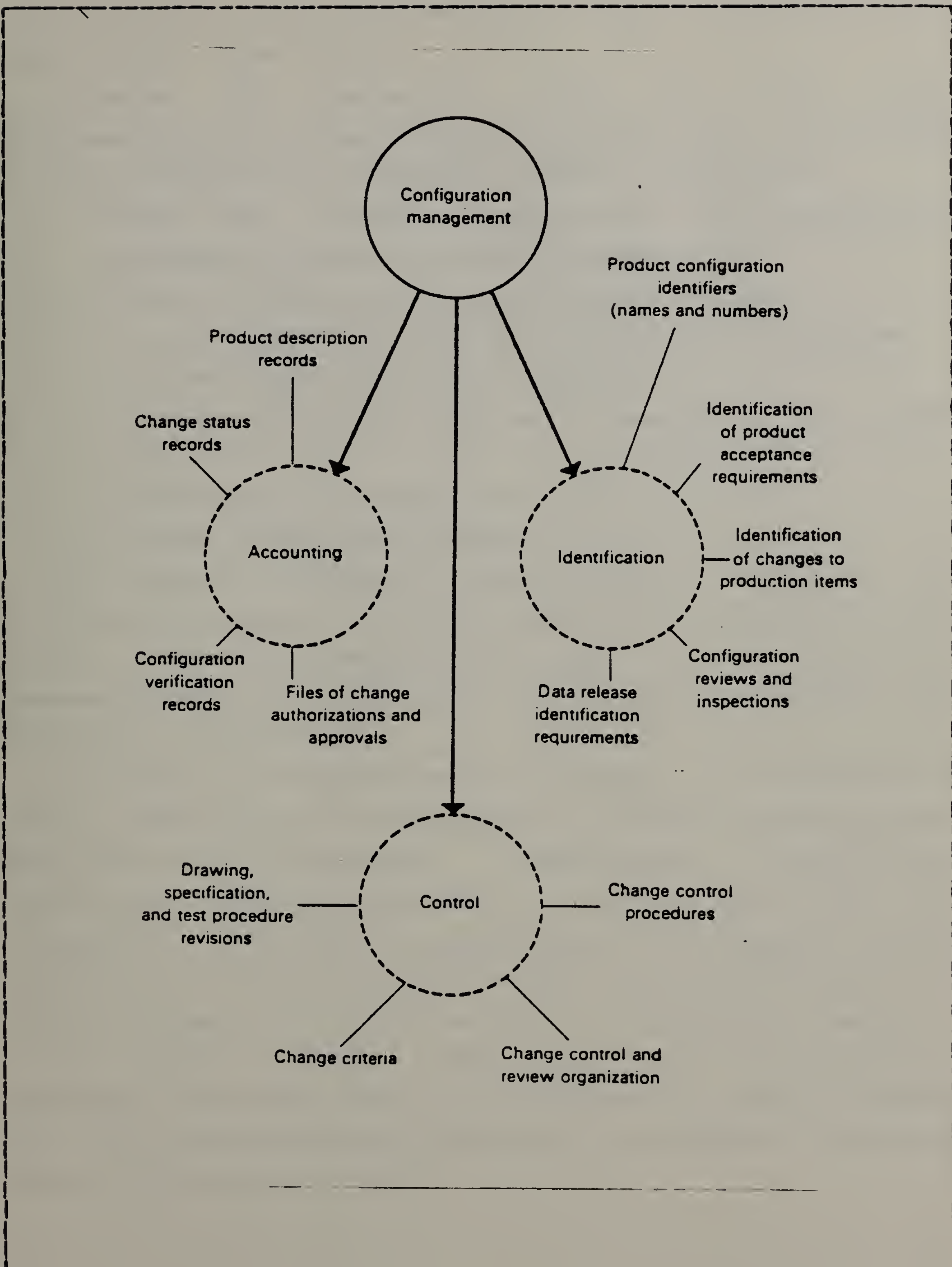


Figure 2.1 CONFIGURATION MANAGEMENT INTERRELATIONSHIPS.

design data and the fabricated and tested configuration of the CI/CPCI. [Ref. 12]

Samaras and Czerwinski state in their book, "Fundamentals of Configuration Management", the key features in the configuration management process. They are:

1. Early and complete definition of Configuration Management goals, scope and procedures.
2. Speed in evaluating and processing changes.
3. Accurate identification and accounting of changes.
4. Complete descriptions of changes.
5. Close coordination among key elements of the project team.
6. Cooperative and responsive buyer.
7. Minimum labor requirements.

To achieve effective configuration management the configuration manager must be independent of quality assurance, production, engineering, etc. The separation is necessary to achieve unbiased control and to prevent any conflicts of interest.

To assist the Configuration Manager, a Configuration Control Board (CCB) is established. The CCB includes representatives of production, engineering, contracting, purchasing, quality assurance, maintainability and data processing. The CCB is responsible for complete change evaluation, change planning, change incorporation and as a result is usually the final authority on proposed changes.

A typical Program Office, and where Configuration Management functions within that office, is shown in Figure 2.2. The GPS configuration management structure is detailed further in chapters 4 and 5.

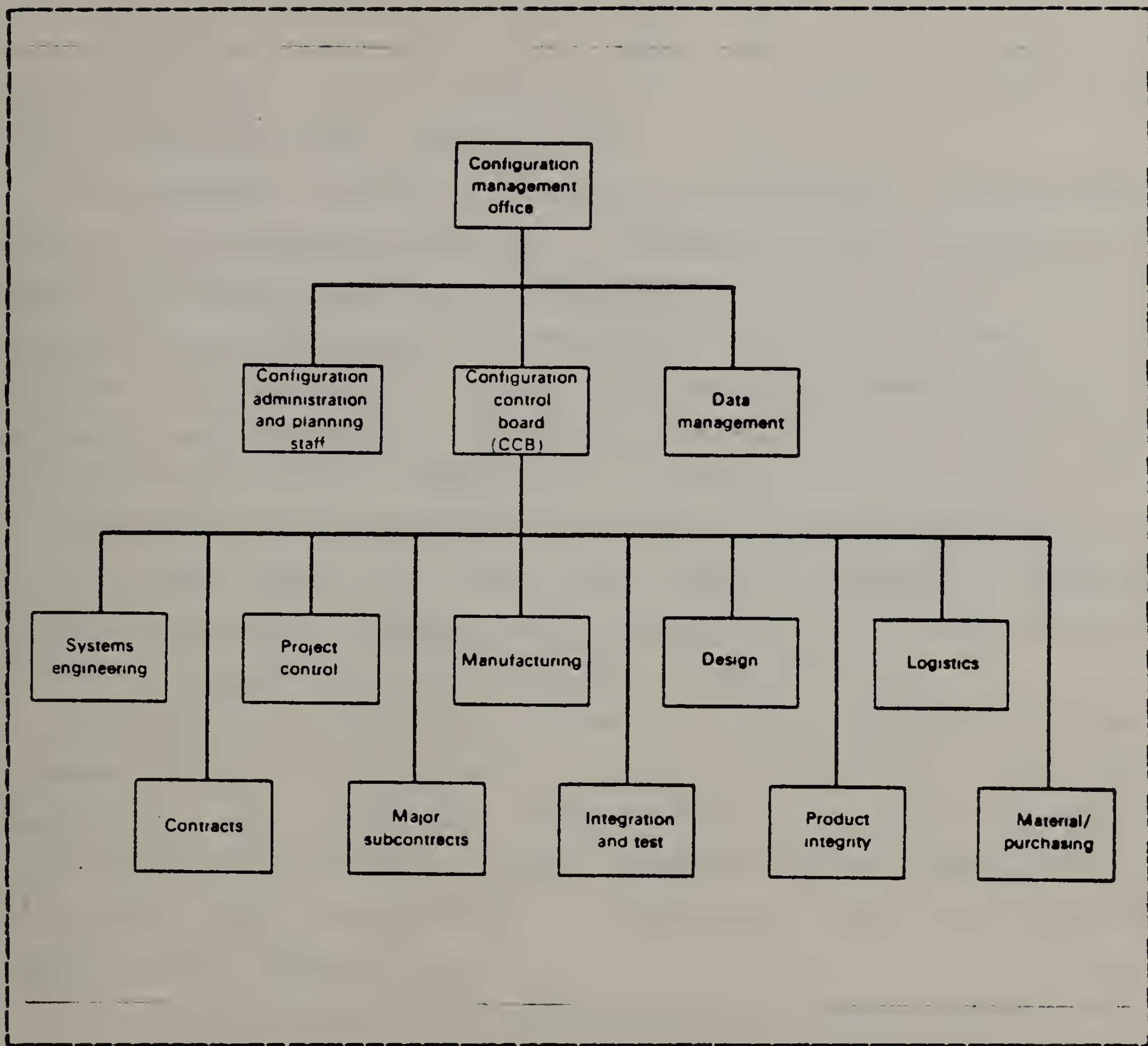


Figure 2.2 CONFIGURATION MANAGEMENT COORDINATION.

B. HARDWARE AND SOFTWARE

In early applications of computers to military systems, the software's role was essentially as an instruction book and the cost of the software was minimal.

Recently, embedded computer software systems have become a higher fraction of the total military development cost. As a result, a reversal of software and hardware roles has developed. Software has evolved from being the computer's

set of instructions to BEING the system. Software now contains the description of what the total system is supposed to do and the hardware is the means through which the instructions are carried out.

The result is that software is a dominant and crucial piece of the computer system. Software clearly warrants at least the same degree of development, discipline, quality assurance and configuration management as the hardware. The problem we face today is that many managers see software as esoteric and mysterious, causing greater anxiety among their numbers than the more familiar hardware.

Proof of the managerial inattention to software surfaced in 1975 as a result of the Johns Hopkins University Applied Physics Laboratory (APL) and the MITRE Corporation studies of the DOD weapons systems software management.

The MITRE Corporation revealed that software problems stemmed from the fact that a lack of discipline and engineering rigor applied consistently to the software acquisition activities. Some specific areas identified in the study that contributed to software cost and schedule growth were: [Ref. 13]

1. Poorly formulated initial software requirements.
2. Changing requirements and requirements growth during the development phase.
3. Improper use of standards and guidance documents in specific procurements.

The Applied Physics Laboratory study resulted in 17 recommendations all addressed to different topics. Three that pertain to configuration management were: [Ref. 14]

1. Major computer software involved in weapons systems should be designated "configuration items" and be deliverable during full scale development.
2. Use top down design, specifically, the use of modular software architecture.

3. The contractor should be required to apply a higher set of engineering practices to the detailed design and programming phase of development. This includes a set of standards covering program structure, size, control, interface, formal conventions on data base management and demonstration that the standards are reinforced in practice.

An important aspect that should be understood is that every post delivery change to software is not a maintenance action but a change to the design of the delivered package. Software programs do not fail as hardware systems do. Zeroes and ones do not wear out. Software systems have no need for classical maintenanace. The inevitable results of these modifications are unnecessary "down" time of the system and unwarranted additional costs.

The Program Manager's job is not easy when dealing with software. The Program Manager must realize software and hardware are both configuration items. He must determine how, when, and by whom changes to delivered software can be made.

The Program Manager must decide how much Preplanned Product Improvement will prevail after the CPCI is delivered. Changes after program delivery must be provisioned since these changes result in partial or total revision of the original software. Consideration must be given to documentation, configuration control, distribution of the changes, facilities used, scope of the changes, change schedules, effected activities, etc. Overall the Program Manager must truly appreciate the nature of the software and any modifications to it.

The point that software and hardware are configuration items can not be over emphasized. In the case of GPS, changes to software and hardware can be placed into two classifications (IAW AFR 800-14 and MIL-STD-483). These

changes are referred to as Class I (changes that affect the current configuration) or Class II (changes not affecting Class I criteria such as document typos, misspelling, clarifying notices, etc.). [Ref. 15]

Requirements for documentation vary depending on the phase and complexity of each CI/CPCI and the change itself. Basically, documentation falls into three categories, according to NAVMATINST 4130.1B (draft): [Ref. 16]

1. The documentation forwarded to the change installing activities as a package with the implementing directive/order involved to properly install the change.
2. The documentation required by the technical, training, maintenanace and supply management organizations to properly control and support each change.
3. The documentation required by the user activities to properly operate and maintain the CI/CPCI after the change is installed.

In the case of software, the "NAVSTAR Global Positioning System Operational/Support Configuration Management Procedures" (draft) [Ref. 17], specifically addresses computer program configuration item documentation. CPCI documentation comprises two disinct areas:

1. Documentation, including flow charts, engineering data (design, test, interface specifications) etc., required in the development or testing of a computer program. This documentation will be identified with a CPIN related to the basic CPCI.
2. Documentation that instructs the user so that he can operate or load the computer programs. This type of documentation will be as a technical order.

NAVMATINST 4130.1B (draft) does address the contractor's responsibilities which is consistent with item 1 above. NAVMATINST 4130.1B says," the contractor is responsible for

preparing the detailed production drawings and computer software, manufacturing the change hardware and firmware and assembling the technical documentation, hardware, firmware and computer software into a retrofit kit to meet the delivery schedule established by the CCBD."

The overall differences between software and hardware configuration control documentation is not significant. All data delivered under a hardware or software contract is defined in the Contract Data Requirement List (CDRL), DD Form 1423. The point is that software is a configuration item and requires the Configuration Management emphasis that hardware now receives. The GPS management realize this fact which is witnessed in the User Equipment configuration control structure. All computer program changes must proceed through two more configuration sub-boards than hardware related changes. Software in the GPS structure is scrutinized by the User Equipment Computer Program Screening Panel (UE CPSP) and the User Equipment Computer Program Configuration Sub Board (UE CPCSB) before it proceeds to the User Equipment Joint Configuration Control Board (UE JCCB). The fact that software changes are design changes not maintenance actions requires the additional analysis offered by these additional configuration sub-boards.

The GPS hardware/software configuration control structure is managerally sound in design. The ultimate success of the program rests with the involved agencies who must realistically adhere to the provided policies and procedures of the Operational/Systems Configuration Management Procedures.

C. EXISTING GUIDELINES FOR CONFIGURATION CONTROL

The NAVSTAR Global Positioning System Operational Support Configuration Management Procedures (O/S CMP) is just one publication the GPS configuration control structure must follow. Basically, the O/S CMP expands on the procedures outlined in the GPS Joint Services Support Management Plan (JSSMP), Integrated Logistics Support Plan (ILSP) and the Computer Resources Integrated Support Plan (CRISP). Overall the GPS configuration control structure must abide by; Mil-Std-480A (Configuration Control- Engineering Changes, Deviations and Waivers), Mil-Std-481 (Configuration Control Engineering-Changes, Deviations and Waivers short form) and MIL-STD-483 (USAF Configuration Management Practices, Systems, Equipment, Munitions and Computer Programs).

Besides following the GPS regulations, the Navy must act in accordance with their own instructions and regulations. Specifically they are; NAVMATINST 4130.1 (DOD Configuration Management Procedures) and YEL 80-122 (Navy Computer Resources Management Plan (the Navy annex to the GPS CRISP).

III. BASELINE FOR GPS/USER EQUIPMENT

A. GENERIC BASELINE

The phase 3 GPS User Equipment will be comprised of several integral components, each of which will be designated for usage on multiple platforms. These common components are referred to as Line Replaceable Units (LRU), which, in turn, are composed of a set of common hardware replaceable modules and chassis components known as Shop Repaceable Units (SRU).

This approach is consistent with the overall strategy of minimizing Life Cycle Cost (LCC) by minimizing the number of platform unique elements, through the use of common modules, while satisfying the varying host vehicle unique requirements. The integration of GPS UE onto Navy platforms will be achieved by selecting the appropriate combination of LRUs necessary to meet the individual platform requirements. [Ref. 18]

The GPS system configuration management is managed through a series of time sequenced events known as baselines. The foundation of a CM system exists in baseline management defined as the application of technical and administrative direction to designate and control the documents which formally identify and establish the configuration identification of a CPCI or CI at specified times during its Life Cycle i.e., functional, allocated, and product baselines.

Configuration identification is the current approved or conditionally approved technical documentation for a configuration item as set forth in specifications, drawings, and associated lists and documents. At any time in the life

cycle, the previously established baseline, together with approved changes, constitutes the current configuration identification of the system equipment. The identification of the GPS CIs/CPCIs is the basis for configuration control. The required configuration of the CI/CPCI is identified at this time by its development specifications. The achieved configuration will be identified by its product specification, which cannot be fully addressed until receipt of the GPS production specifications, drawings, and software documentation targeted for DSARC III in FY 84. Therefore; the configuration control management structure has been planned using a generic baseline. This puts the necessary pieces in place and will require only minor modification once the product baseline is finalized.

The following provides a general description of the GPS UE at the LRU level. (major CIs)

B. GPS LRUS

1. <u>Antenna/Antenna Electronics</u>: The antenna and antenna electronics are separate LRUs. There are two generic types of antennas available for use as part of the UE, they are:

   a) Fixed Reception Pattern Antenna (FRPA)

   b) Controlled Reception Pattern Antenna (CRPA)

The FRPA is a simple omni-directional antenna with a deep null at the horizon. The CRPA is a multiple element array antenna with "steerable nulls" that has a similar receiving pattern to the FRPA under ambient jamming and Low Level Radio Frequency Interference (RFI) conditions. Additionaly, these CRPA antennas can sense jamming energy arriving from a specific direction and quickly adapt their receiving patterns to create nulls in those directions. The number of jamming sources that can be nulled is dependent on

the number of antenna elements. The operation of the CRPA is self-contained and does not require any host vehicle information or interaction.

2. Control Display Unit (CDU): The GPS Control Display Unit (CDU) provides the operator with the capability to control the UE, input data, and observe UE generated outputs. The GPS CDU contains operating controls, a data entry keyboard, and alphanumeric displays. The CDU will not be required when integration of the Set is in a platform that has an existing CDU that can be utilized for GPS.
3. Flexible Modular Interface (FMI): The Flexible Modular Interface (FMI) will perform the interfacing function between the RPU and the user platform. The FMI will provide the GPS UE with the capability of interfacing with analog and digital avionics equipment and may contain a microprocessor for data manipulation where required. The FMI for each platform will be designed to meet the unique requirements of that particular platform. These unique designs will be based on the strategy of utilizing replaceable components common to all FMIs. This functional partitioning approach will allow for commonality in the use of the other LRUs across many Navy applications while supporting platform unique requirements in the platform unique FMIs.
4. Receiver Processor Unit (RPU): The RPU performs the signal and data processing. Three variations, each a separate LRU, make up the RPU family:
   a) High dynamic, fast signal acquisition (5 channel)-for high performance aircraft and submarines
   b) Medium dynamic (2 channel)-for surface ships, helicopters, and medium performance aircraft

c) Manpack/Vehicular (1 channel)-for infantry and vehicular operations.

Each of the RPUs shall perform the following functions:

i) Receive and amplify signals transmitted by all visible satellites

ii) Select and acquire signals from the four desired satellites

iii) Track the acquired navigation signals (four simultaneously for the 5 channel, four sequentially for the 1 and 2 channel RPUs)

iv) Extract information contained in the received satellite data

v) Measure the signal propagation error

vi) Provide resistance to jamming

vii) Compute position, velocity, and time

viii) Generate self test signals for UE fault isolation

ix) Provide additional functions as required by platform configuration and mission.

C. GPS UE CAPABILITY OPTIONS

A major variable in determing the specific LRUs required, the overall GPS UE procurement, and individual platform installation is the extent to which the GPS UE is integrated within the host vehicle. This in turn has implications regarding the existing platform capabilities which GPS will enhance, or the new capabilities it will provide to the platform. The proposed hierarchy of GPS UE capability options available to the platforms are:

1. Stand Alone: This option provides stand alone GPS position and velocity data to the user. The CDU is the sole source of information entry and display. The baseline equipment required consists of:

a) Antenna/antenna electronics (FRPA)

b) Receiver/processor unit (1 channel)

c) Control/display unit

2. Area Navigation and Instrument Landing: This option provides the capability to perform enroute waypoint navigation in which waypoints are either preset or manually entered. In addition, instrument landing approach capabilities will be provided to determine deviation from course and glidepath as well as range and bearing to waypoints. The highly accurate GPS three dimensional position data could be used for non-precision instrument approaches to any airfield whose coordinates are known, including uninstrumented and temporary airfields. The baseline equipment required consists of:

a) Antenna/antenna electronics (FRPA)

b) Receiver/processor unit (2 or 5 channel)

c) Flexible modular interface

d) Control/display unit

3. Alignment and Calibration: This option provides the capability of utilizing the GPS UE to update the platform on-board Inertial Navigation System (INS) or other navigational aids. Also the other navigation sensors on-board can be used to update or verify GPS information. The baseline equipment required consists of:

a) Antenna/antenna electronics (FRPA)

b) Receiver/processor unit (2 or 5 channel)

c) Flexible modular interface

d) Control/display unit

4. Computer Update: This option provides the capability of utilizing the GPS UE navigation data to update the platform's central or weapons computer. This capability will enhance the functions of the systems

interfaced to these computers. The baseline equipment required consists of:

a) Antenna/antenna electronics (FRPA)
b) Receiver/processor unit (2 or 5 channel)
c) Flexible modular interface
d) Control/display unit

5. <u>Anti-Jam Enhancement</u>: This option provides the capability of enhancing the anti-jamming capabilities in the GPS UE, there-by providing accurate position, velocity and time data in a hostile environment. Implementation of this option could provide the platform with an anti-jam capability improvement between 10 to 30 decibels [Ref. 19]. The baseline equipment required consists of:

a) Antenna/antenna electronics (CRPA)
b) Receiver/processor unit (2 or 5 channel)
c) Flexible modular interface
d) Control/display unit

D. COMPUTER PROGRAMMING

Computer programs for the GPS UE shall be designed in accordance with the following requirements: [Ref. 20]

1. Each computer program error allocation when combined with the related hardware error allocation, shall not degrade the navigational accuracy.
2. Computer programs that provide navigation and timing data shall be designed to provide a graceful degradation of accuracy as measurement data becomes unavailable or unreliable. Separate degraded-mode programs shall not be utilized to provide this capability.
3. Computer programs shall be designed in a modular fashion to allow for maximum computer program common-

ality among all Sets and localize the impact of changes.

4. Assembly language may only be used to implement functions which cannot be coded efficiently in a high-level program language.
5. All computer programs and corresponding documentation shall be written in a self-consistent and uniform notation.
6. The Set executive computer programs shall be partitioned to distinctly isolate the set-unique exectutive control logic. The remaining general-purpose executive modules shall be as common as possible among all-sets.
7. All computer programs within all the user segment sets shall utilize a common machine-language instruction set.
8. All computer programs within all the user segment sets shall be written in a single high-level programming language.
9. Microcode and firmware shall be considered as software for definition purposes.

The configuration Control Management Plan for DoD common and Navy Unique CI and CPCI at the present time is based on the allocated baseline. Configuration Control will become a management of the product baseline after DSARC III. The considerations of baseline management are:

1. Determine the need for a change.
2. Prepare the change justification package.
3. Conduct in-depth impact analysis.
4. Review proposed changes with subsequent approval/disapproval.
5. Update approved change material
6. Incorporate approved changes in CI/CPCIs and its documentation.

Adherence to well defined procedures is the key element in controlling and documenting changes to baselines. The configuration control plan is an attempt to define and establish these procedures.

IV. CONFIGURATION CONTROL MANAGEMENT STRUCTURE FOR DOD COMMON

A. DOD CONFIGURATION CONTROL

Configuration control is the systematic evaluation, coordination, approval, disapproval and implementation of approved changes to any baseline [Ref. 21]. Formal control of the configuration of a system or configuration item/computer program configuration item (CI/CPCI) begins with the establishment of the first baseline and continues throughout the life cycle

The objectives of configuration control are to attain and maintain: [Ref. 22]

1. An optimum degree of design and development latitude while introducing controls at the appropriate time, degree and depth during each phase of the life cycle of the CI.
2. Efficient processing and implementation of configuration changes.
3. Complete, accurate and timely documentation of the CI's configuration consistent with total program needs.
4. The required level of operational readiness, supportability, interchangeability and interoperability through standardization and control of design and change proliferation.
5. Monitor life cycle cost effects of ECPs.

Government configuration control is governed by DOD-STD-480 or MIL-STD-481, as appropriate. These standardization documents help identify the full impact of proposed changes to established configuration baselines and their subsequent current configuration identification.

Control of all changes is a coordinated process of documentation, justification, systematic evaluation, decision, release, implementation, reporting and monitoring between the office of primary responsibility (OPR) and the contractor for as long as the contractor is involved with the program. The OPR, during development and transition, is the JPO and the OPR becomes the JSSMO after PMRT in FY 87.

Proposed changes may be initiated by the OPR, the contractor or any activity that has an interest in the CI. Activities outside of the OPR must submit changes to the OPR for consideration. The OPR's control over proposed changes is limited to those that have an effect on the current configuration identification of the CI. The method for proposing changes, the documentation which describes the CI and the related criteria which limits the OPR's control are clearly defined in the contract requirements.

All change proposal initiators must establish the basic factors of ; the description of the change, need for the change and the conditions of accomplishment capability (i.e. change accomplishment location, capability requirements for personnel and the time schedule). The change initiator is responsible by the contract to establish the basic factors, determine the applicable criteria with supporting data and evaluate the criteria and data.

Change proposals that do not offer significant benefit to the government are cancelled. Necessary or beneficial changes are those which; correct errors or deficiencies, resolve non-availability of parts and components, effect substantial life cycle cost savings, prevent stoppage or slippage in schedules, effect advancements in technology and any change that changes the mission element need. [Ref. 23]

The OPR is responsible for establishing priorities and time spans for change proposal processing, based on the nature and relative urgency of the change. The proposed

priority is assigned by the initiator and stands unless the OPR has a valid reason for changing it. The OPR establishes detailed operating procedures, configuration status accounting records and other appropriate progress techniques necessary for timely processing of the change proposal. The OPR controls the processing of changes to avoid any unnecessary delays which could prevent timely incorporation of changes during production, result in increased acquisition costs or deny DOD activities benefits from the change. The OPR can withold a change proposal's "production cut-in" for subsequent, rather than current, production lot to fulfill the requirement of giving the contractor sufficient notification in order to plan and perform turn around and recyclic engineering and production actions.

The OPR controls the flow of change proposals through use of a "log" that is used to establish realistic targets for each proposal and provides the basis for program management evaluation as to the expeditious flow and status of each change.

To provide for proper change proposal coordination, evaluation, processing, approval, disapproval and implementation cognizant DOD components establish a Configuration Control Board (CCB). The CCB is the official agency to act on all changes.

The CCB is composed of chartered representatives from all affected fields such as engineering, contracting, quality assurance, etc. Each representative presents his official position, based on his specialty, to the CCB. The CCB chairman, usually the Program Manager (PM), makes the final decision on all changes which are documented as CCB Directives (CCBD) or CCB Requests (CCBR). The CCBD/CCBR's contain each CCB member's opinion, the implementation need date, the implementation schedule, contractual methods and identity of responsible activities.

All change evaluations take into account the relative merits of production cut-in and inventory retrofitting versus operating and supporting multi- configurations of the CI. The impact of not making the change at all is always considered as an alternative.

Changes beyond the scope of the CCB's authority such as changes to the program's production schedule, mission element need or program cost, require Office of the Secretary of Defense (OSD) or DOD component approval.

B. GPS CONFIGURATION CONTROL

1. Major Agencies

The major agencies for GPS are: [Ref. 24]

a) Office Of Primary Responsibility (OPR): The OPR for the operational/support configuration management procedures is the GPS Joint Services System Management Office (JSSMO), after PMRT scheduled for FY 87. All proposed changes to the operational/support configuration management procedures are submitted from the respective service command to the GPS JSSMO for final action.

b) Services Involved: The prime GPS users are the Air Force, Army, Navy, Marines, NATO and Defense Mapping Agency (DMA). User equipment (UE) test host vehicles include the USAF B-52 bomber and F-16A fighter; the Navy SSN-700 submarine, CV-59 aircraft carrier and the A-6E attack aircraft; the Army UH-60 helicopter, M-60 tank and the soldier himself (manpack 1 channel version). DMA and NATO test host vehicles will be identified at a later date.

c) Contractors: During Phase One (Demonstration and Validation) of the overall GPS program schedule

four contractors were selected for UE development during Phase II-A. Two contractors were selected from these four for UE full scale development during Phase II-B: Magnavox and Rockwell-Collins.

d) <u>Executive Service</u>: DOD single manager policies direct the services to centralize management and configuration control when multi-service resources are involved. As a result, the Air Force has been designated the Executive Service (single manager) for the GPS program and is responsible for the centralized management and configuration control of GPS hardware and software systems.

The prime focal points for GPS are: [Ref. 25]

1. Headquarters USAF: Provides management of GPS computer resources and ensures policies and procedures are consistent with applicable regulations and directives.
2. Air Force Systems Command (AFSC): Responsible for the development, acquisition, transfer and turnover of the GPS system. The responsibility has been delegated to the Space Division (AFSC/SD) and AFSC/SD has formed a Joint Program Office (JPO) to manage GPS multi-service involvement.
3. GPS Joint Program Office (JPO): The JPO has full management responsibilities prior to Program Management Responsibility Turnover (PMRT). The JPO is the GPS System Manager (SM) up to the PMRT date, for the overall program.
4. Air Force Logistics Command (AFLC): AFLC implements all applicable instructions, regulations and directives after PMRT and AFSC turnover, for DoD common UE items. AFLC has designated Warner Robins Air Logistics Center (WR-ALC) as the post-PMRT Systems Manager (SM). Because GPS is a joint service

program, the Navy and Army will have representatives at WR-ALC.

C. GPS CONFIGURATION CONTROL RESPONSIBILITIES PRIOR TO/AFTER PMRT

The objective of PMRT is to accomplish an orderly, timely and efficient transfer of overall Program Management Responsibility (PMR) at the earliest practicable date during the Production and Deployment Phase (Phase 3). This is scheduled for FY 87.

The Transfer Working Group (TWG), established by the Program Manager, develops the schedule, coordinates the transfer and fabricates an overall transfer plan for the program.

PMRT planning for joint service programs justifies the interrelationships and functional responsibilities of the executive and supporting services that become effective at the PMRT date. Therefore; after PMRT the Army and the Navy will report to the JSSMO vice the JPO. The USAF, as stated earlier, is the GPS Executive Service.

Prior to PMRT, the JPO has configuration management responsibilities for the entire GPS program. The GPS JPO has developed and implemented a cost effective configuration management program by utilizing the contractor's internal configuration management practices. The JSSMO begins monitoring the configuration management at the beginning of Phase III and stops monitoring after PMRT when it assumes total program configuration management responsibility.

The Transition Phase begins when the JPO reponsibility is gradually turned over to the JSSMO and continues to the PMRT. The GPS JPO Joint Configuration Control Board (JCCB) retains final approval for all configuration changes during the Transition Period. The configuration management function continues to be administered by the GPS JPO with

increased participation from the support commands and user organizations until the PMRT date when all GPS system baselines and related documentation are finalized then transferred to the JSSMO WR-ALC.

After PMRT the JSSMO at WR-ALC has full joint service authority and responsibility for configuration management. The JSSMO has configuration control of every GPS unit except for the Flexible Modular Interface (FMI) and its internal software which is unique to a single host vehicle. In this case the FMI is managed by the host vehicle System Manager (SM) or Program Manager (PM).

The Joint Service System Manager (JSSM) establishes the GPS Joint Configuration Control Board (JCCB) at Warner Robins Air Logistics Center (WR-ALC). The GPS JCCB is tasked with controlling the configuration for the entire GPS hardware and software systems except for the host vehicle unique FMI units mentioned above. The JCCB is the regulatory body for the subordinate configuration control boards shown in Figure 4.1.

The subordinate configuration control boards functions are: [Ref. 26]

1. GPS JCCB Working Group: The working group serves as the technical staff to the GPS JCCB and reports directly to the chairman.
2. GPS Control Segment Configuration Control Board (CS CCB): The CS CCB is responsible for all configuration control of the Control Segment with approval authority to approve Class 1 changes that do not impact the space vehicle and/or user equipment.
3. GPS Control Segment Computer Program Sub Board (CS SPCSB): The CS CPCSB may approve Control Segment Class 2 changes on CIs and computer program configuration items (CPCI's) identified in the CS CPCSB charter.

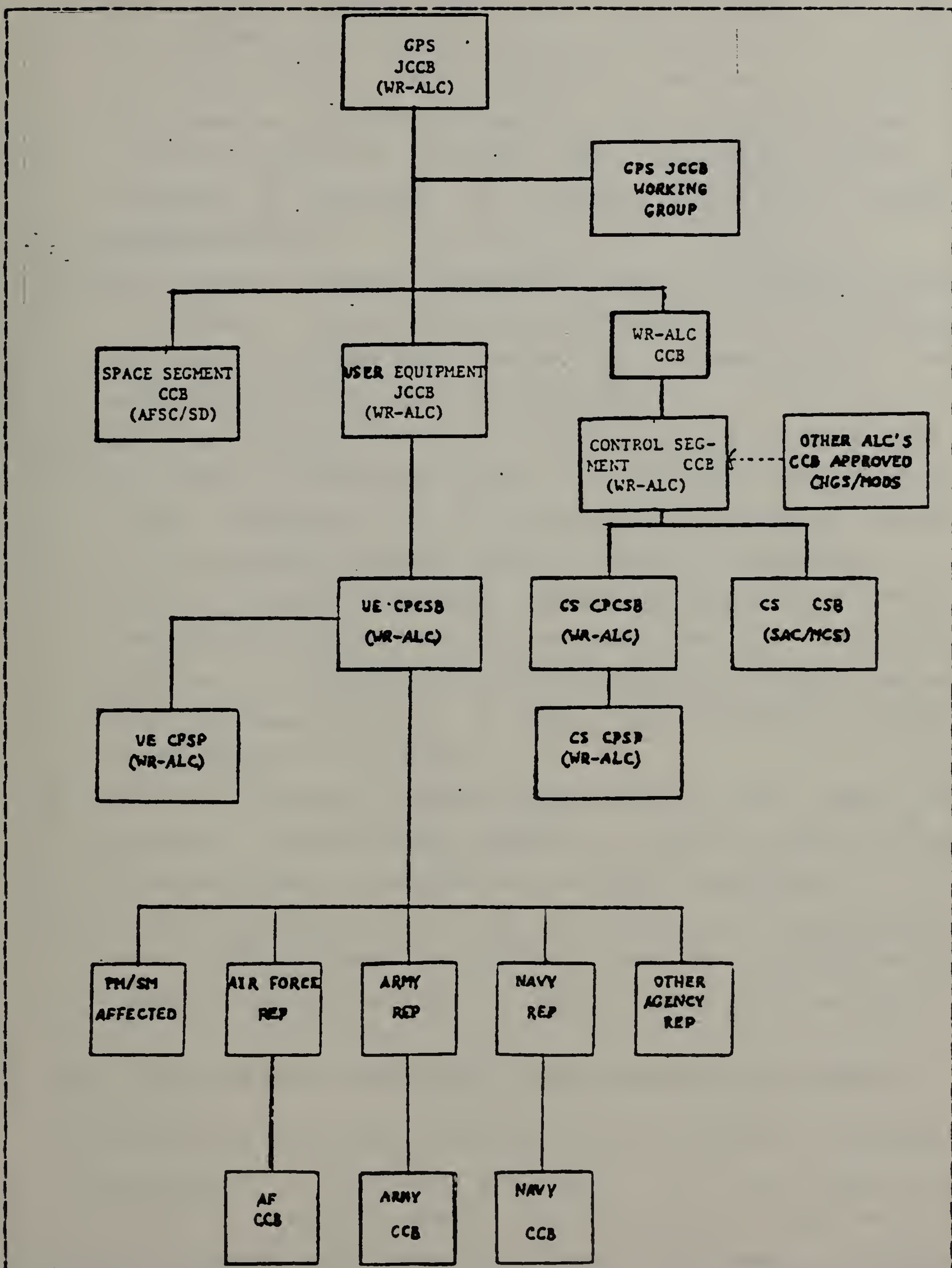
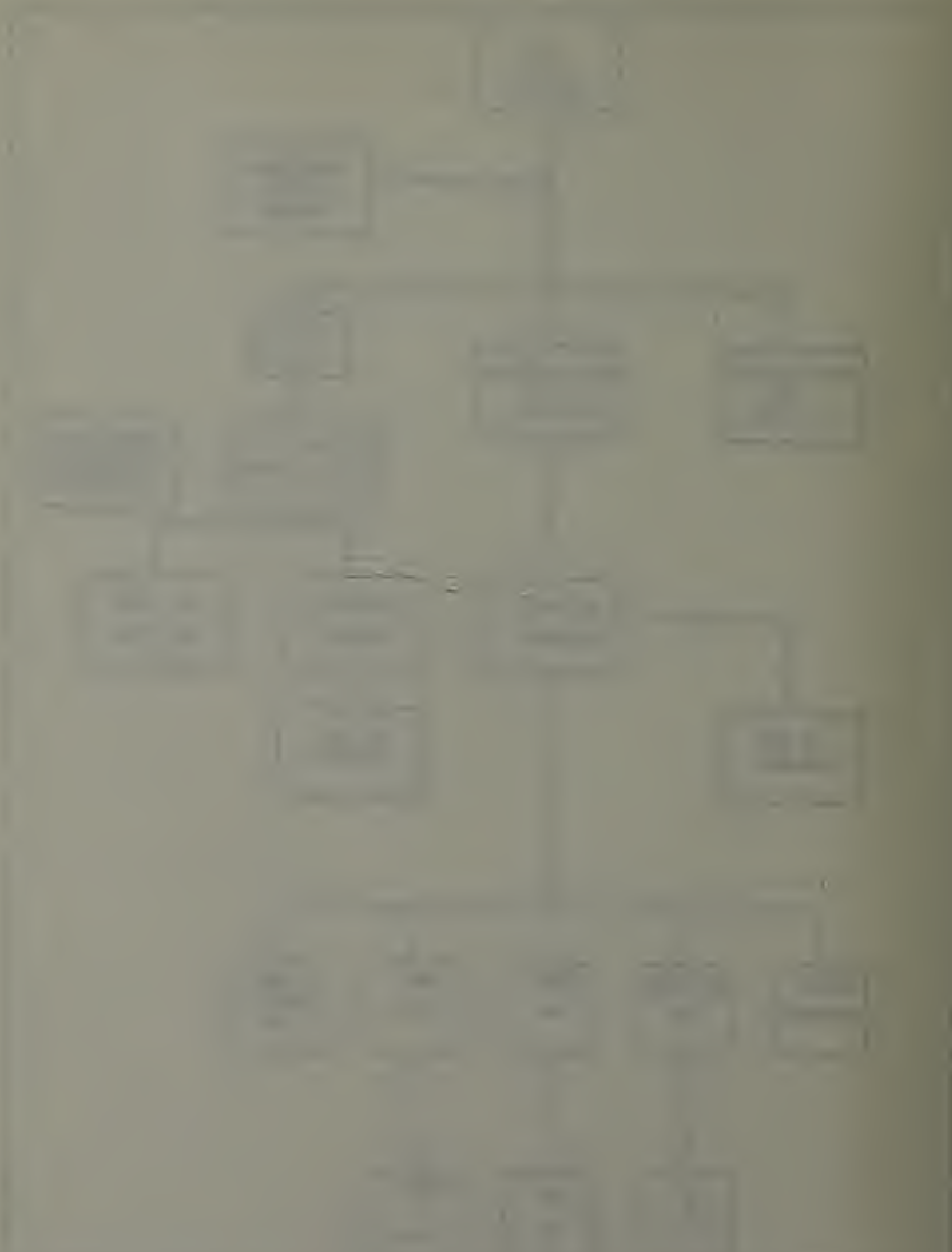


Figure 4.1 GPS CONFIGURATION CONTROL STRUCTURE.



4. GPS Control Segment Configuration Sub Board (CS CSB) at SAC/MCS (Strategic Air Command/Master Control Station)--The CS CSB at SAC/MCS operates similar to the one at WR-ALC except it may approve class 2 organic software changes and emergency class 1 changes if required to maintain satellite orbital configuration.
5. GPS Control Segment Computer Program Screening Panel (CS CPSP): The CS CPSP is responsible for validating proposed changes and preparing recommendations for submission to the CS CPCSB/WR-ALC.
6. GPS User Equipment Joint Configuration Control Board (UE JCCB): The JSSM chairs the UE JCCB and approves class 1 changes that do not impact the space vehicle or the control segment and all class 2 changes.
7. GPS UE Computer Program Screening Panel (UE CPSP): The UE CPSP functions in the same capacity as the CS CPSP with respect to validation of proposed changes and recommendations to the UE Computer Program Configuration Sub Board.
8. GPS UE Computer Program Configuration Sub Board (UE CPCSB): The UE CPCSB reports to the UE JCCB and may approve class 2 changes on the User Equipment.
9. PM/SM Affected, USAF, USA, USN and other agencies all have CCB's that report to them on configuration control issues germane to their respective service.

D. GPS USER SEGMENT DEFICIENCY REPORT/CHANGE PROCEDURES

User activities below the depot level prepare and submit UE deficiencies and change proposals to the respective service CCB. The flow chart for processing user segment deficiency reports and change proposals is shown in Figure 4.2.

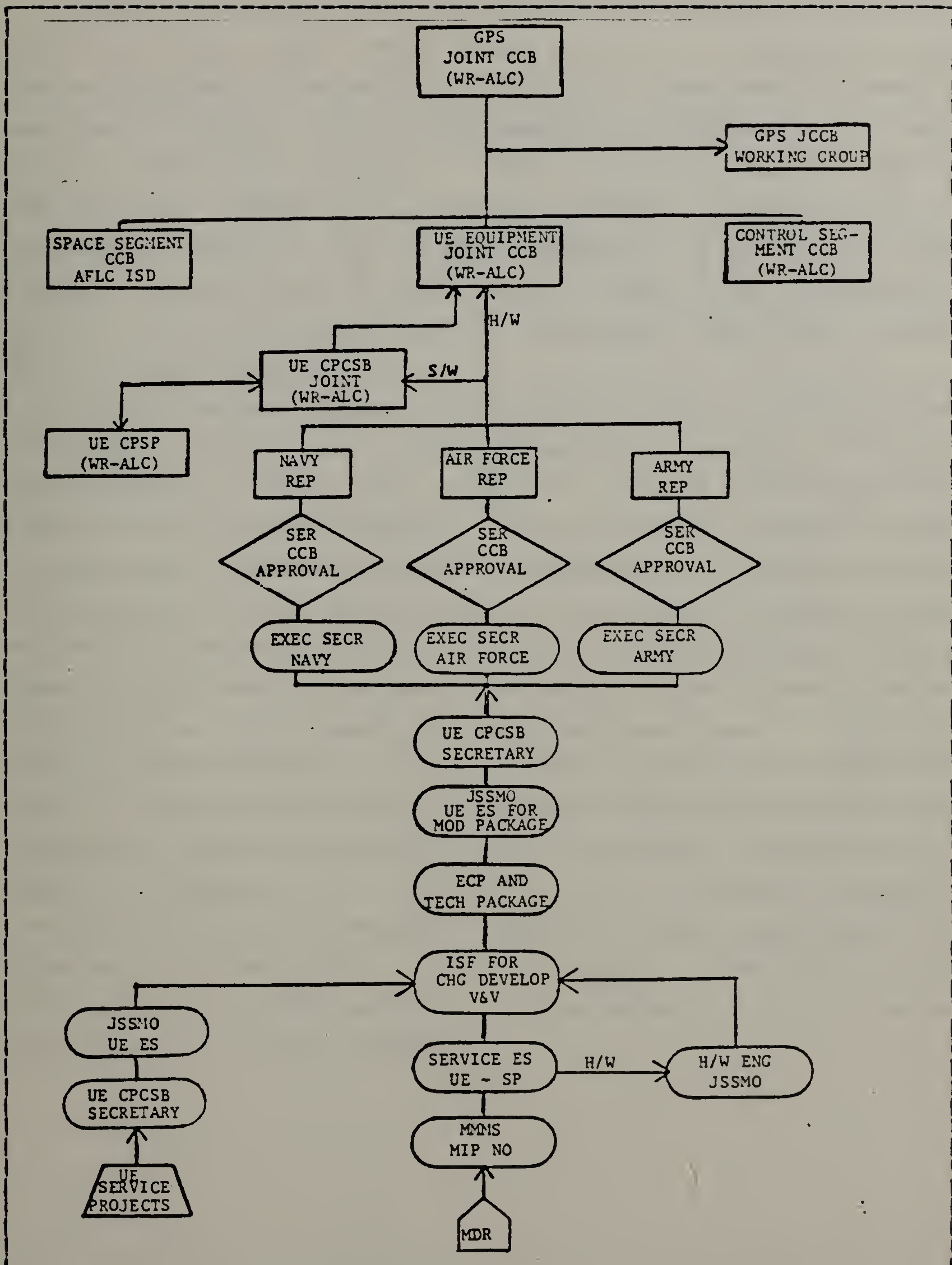


Figure 4.2 USER SEGMENT CONFIGURATION FLOW DIAGRAM.

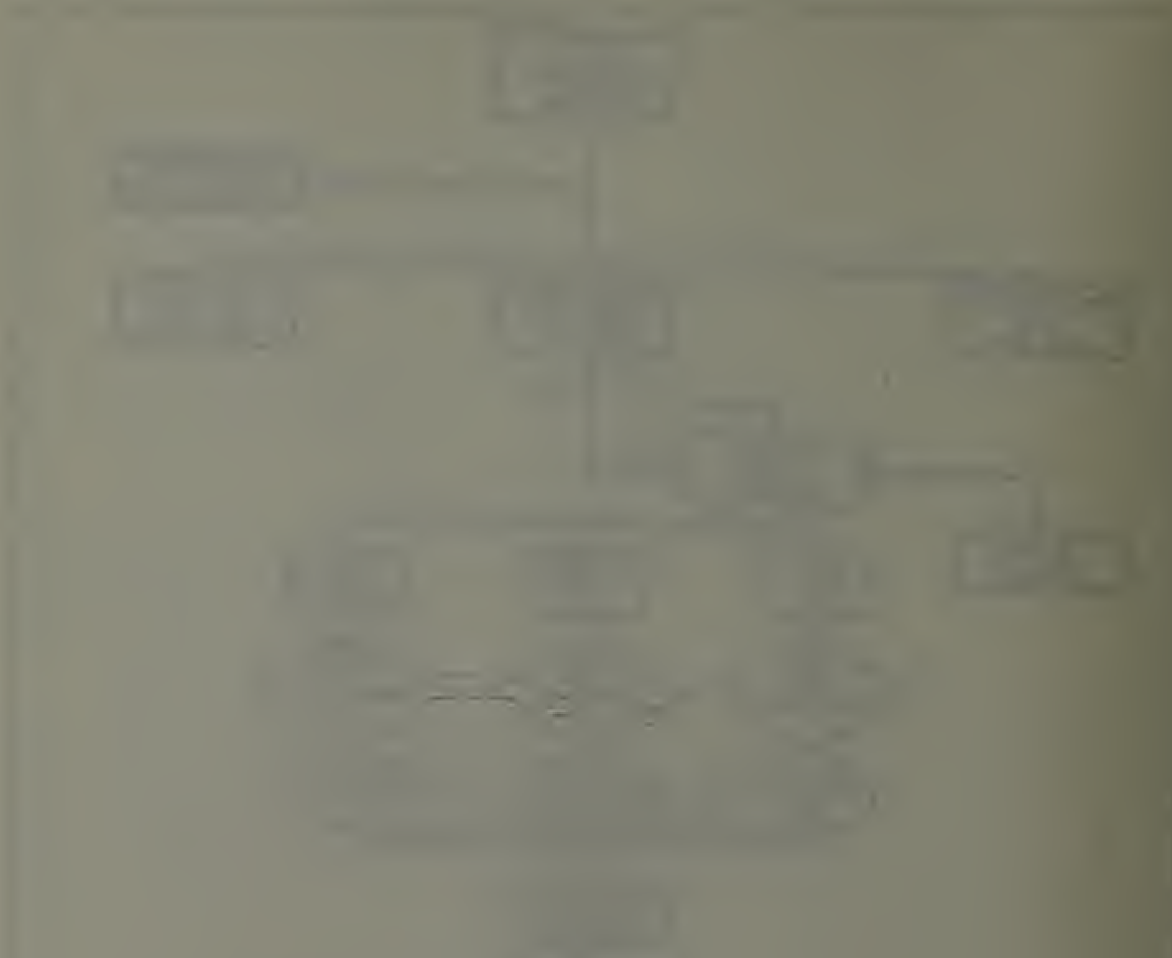


Figure 4.2 points out the successive chain of boards and sub boards that must review then approve or disapprove each change proposal. Depending on priority (emergency, urgent or routine) changes will be implemented individually or held for the next block release. This decision will be made by the JSSM and based on the service system and using activities requirements. If change requests are held for block release a time lapse of one year or more could conceiveably elapse before the user activity witnesses the final product of a change proposal.

Configuration Status Accounting is used to coordinate, record and report all the configuration changes affecting configuration items and computer program configurations items to the Program Manager. MIL-STD-482A governs the use of any data content and format necessary to perform status accounting. Status accounting is a continual process suplemented by Physical and Functional Configuration Audits. These audits should be performed at a time interval determined by the requirement for updated baselines. With the block change concept the audits should precede the implementation of the block change. Status accounting records the baseline (approved configuration) and the implementation status of changes to the baseline. This verifies whether or not the decisions of the GPS CCB's are being implemented as directed. Timely and accurate change reporting by the contractor or GPS activity is paramount for a precise configuration control system.

V. CONFIGURATION CONTROL MANAGEMENT STRUCTURE FOR NAVY UNIQUE ITEMS

This chapter is limited to the function of configuration control for Navy Unique User Equipment Items of the GPS system. Consideration will be given to the proposed management structure to facilitate this function and how this function interfaces with the configuration management function of the DoD common UE segment.

A. MAJOR AGENCIES/RELATIONSHIPS

The United States Air Force is the executive agency for the GPS program, and is responsible for providing centralized and integrated management of DoD common user equipment which will be in multi-service/ agency use. As the executive agency, the Air Force is responsible for maintaining the commonality and standardization of all DoD common equipment. The retention and protection of GPS user equipment commonality and standardization are obligatory management responsibilities. [Ref. 27]

The Navy's GPS Program encompasses the user equipment for aircraft, surface ships and submarines, with the use of all three GPS systems (single channel, dual channel, five channel). The wide application of GPS in the Navy brings into play the three System Commands (NAVAIR, NAVSEA, NAVELEX) and the Chief of Naval Material (PM-1). The very diverse characteristics of the respective operational platforms and weapon systems dictate procedural variations in the implementation of effective management functions. The Navy has specific responsibilities for ensuring the commonality and standardization of software and hardware of

Navy-unique user equipment and for providing support to the Air Force in maintaining commonality and standardization for DoD common equipment.

Figure 5.1 graphically identifies the organizational interrelationships of the Navy System Commands and the JPO, both before and after PMRT. The major effect by PMRT on the support management structure for the Navy is the change from JPO to JSSMC final approval authority.

The GPS JPO has full program management authority and responsibility until the planned PMRT occurs in FY 87. Following the PMRT, those responsibilities will be assumed by the GPS JSSMO located at Warner Robins Air Logistic Center (WR-ALC).

The Navy Support Management Structure prior to PMRT is headed by the Program Manager PME-106-2 and is assisted technically by the SYSCOMs with consultation provided by the CEA, LFAs and the PSSAs. The headquarters element is responsible for setting the overall management policies for the Navy Program, including the design and implementation of the total Navy program organization structure, for delegating administrative and configuration management resposibilities and for providing direction to and funding of program participants. The Navy support management structure remains the same after PMRT except it now reports to the JSSMC via the Navy Configuration Control Board, which will be chaired by PME-106-2.

PME 106 has the overall responsibility and authority for all phases of the Navy GPS program as shown in Figure 5.1. PME 106 is the central management activity responsible for the total Navy acquisition management of the Navy GPS UE program. Responsibilities include Configuration Management, Acquisition Logistics, Specifications, Acquisition, Cataloging, Provisioning, Maintenance and Interservicing, Spares Requirements, Budgeting and Funding, Financial

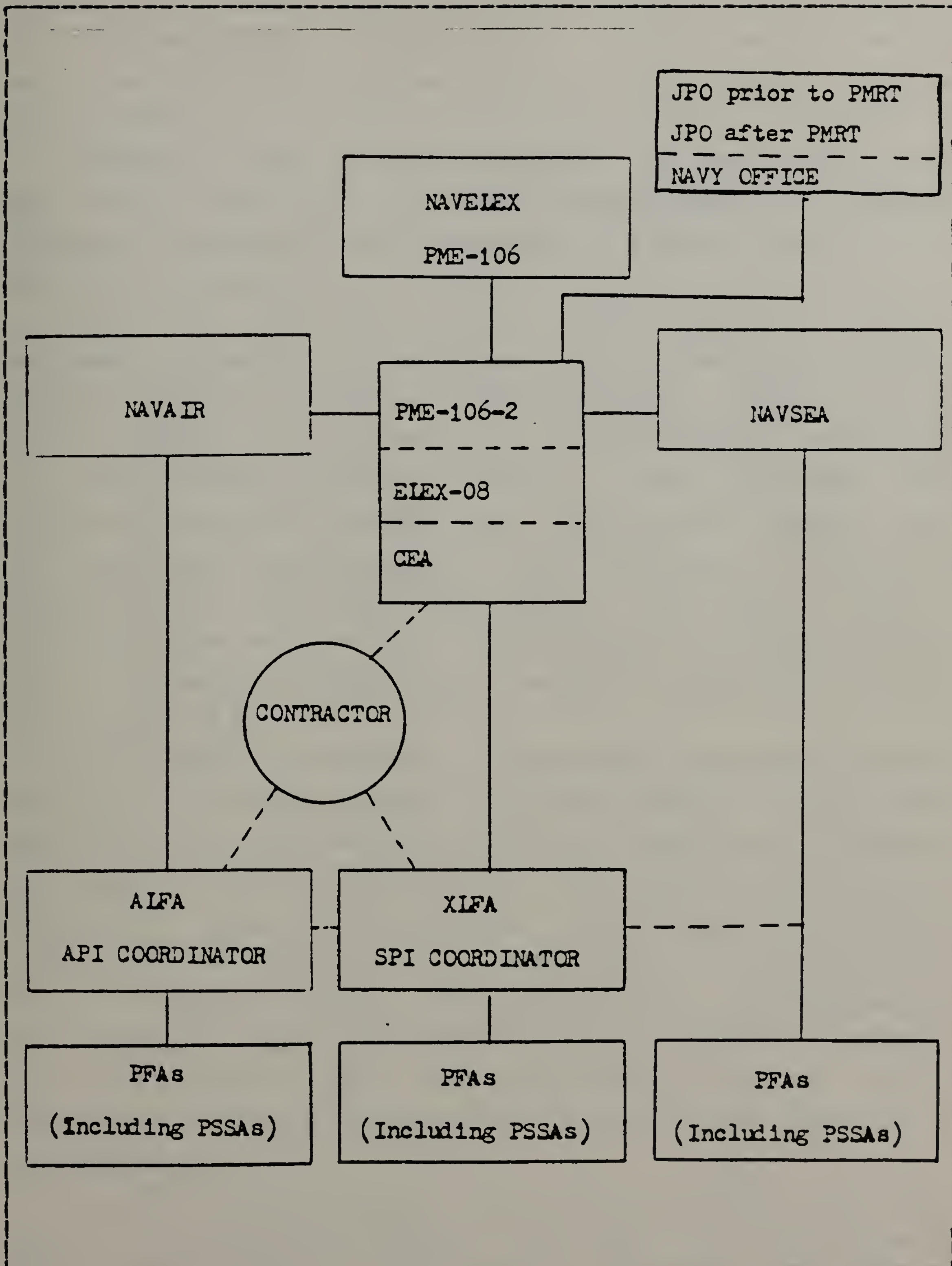


Figure 5.1 SUPPORT MANAGEMENT STRUCTURE.

Management,Training, and UE Installations. PME 106-2 is directly responsible to PME 106 for all GPS related matters and interfaces, and is also the Navy Deputy Program Manager at the JPO.

ELEX-08 is the central management activity responsible for total Navy ILS, Systems Effectiveness Engineering Program, Maintenance Effectiveness and Supply Support of the Navy GPS UE program.

The second principal element of the Navy GPS support management structure is comprised of the designated support activities participating in the development, testing, evaluation, support and utlization of the GPS system. This group of organizations includes the CEA, LFAs and PSSAs with responsibilities for various Navy laboratories, depots, test and evaluation activities and user activities. The active membership of this group will change from time to time as the GPS system evolves from development to ultimate deployment. Organizationally, this element is depicted in Figure 5.1. [Ref. 28]

The contractor position in the support management structure is an advisory member. The contractor is a critical contributor of information concerning design and production management, which ties directly into configuration control management. The contractor will also supply all technical support for the first 2 to 3 years prior to the Navy's take over of organic support. The benefit from the contractors participation, will rely heavily upon the amount of cooperation and effort that the contractor places on the development of the GPS system and the attitude taken in the advisory role.

The GPS creates the need for numerous vertical and horizontal relationships within the Navy for configuration control management. The support structure depicted in Figure 5.1 indicates these relationships and also the single

interface between PME 106-2 and the JPO prior to PMRT and JSSMC after PMRT.

B. CONFIGURATION MANAGEMENT STRUCTURE HARDWARE/SOFTWARE

The Navy configuration management structure was planned around the most complex case. The complexity of the FMI is a product of the amount of embedded computer programs being designed into the FMI and the interface between the FMI and the RPU. The design possibilities lie between two extremes. At the one extreme is what we will call the "smart" FMI, it would be capable of preprocessing all data flowing between the RPU and the host vehical and would not require a standardized I/O interface between the RPU and the FMI. This implies that the smart FMI would contain all the required computer programs to process all data concerning the GPS and be capable of formatting the data for all host vehicles. The design would allow for the maximum commonality among FMIs for the Navy host vehicles. Making this FMI programmable to accommodate the integration aspect of the different host vehicles could, at the extreme, require only one FMI configuration, along with separate software programs that could be loaded into the FMI for each type of platform. At the other extreme is what we will call the "dumb" FMI. In very simplistic terms the FMI would be nothing more than a junction box that would accept data from a standardized I/O interface between the RPU and the FMI and direct the data to the appropriate sensors in the host vehicle. This would most likely require a unique FMI for every platform.

The FMI baseline is presently specified in generic terms and the product configuration baseline will not be established until the production decision is made at DSARC III sometime in FY 84. Both contractors are working under a Fixed Price development contract, which limits the Navy's

input of precise design tradeoffs during the FMIs development. Given this fact the most probable outcome will be to purchase initially the FMIs that are designed by the contractor, and tested during IOT&E. Therefore; to be able to do configuration control management the need to develop plans for the most complex case based on the proposed contractor designs requires a management structure that will be capable of handling both hardware and software configuration control. The structure must also be designed to interface with all the various activities and support elements involved in GPS.

The Navy configuration management structure is headed by the program manager, PME 106-2 and assisted technically by the SYSCOMS, with consultation provided by the System Management Office (SMO) at CEA, System Support Office (SSO) at the IFAs and the Platform System Support Activities (PSSAs). Together these activities make up the headquarters element, which is responsible for the overall program direction. Other Activities provide specialized assistance as required. [Ref. 29] The headquarters element organization relationships are depicted in Figure 5.2.

During the development phase and prior to the establishment of the NCCB, IFA CRBs, the developing contractor submits all change proposals directly to the JPO program manager [Ref. 30], who has final approval/disapproval authority. The contractor performs the configuration control management function and documentation during this phase and coordinates his actions through the JPO.

The Navy Configuration Management Structure (CMS) comes into play during the transitition phase from contractor support to Navy organic support. This structure relies heavily on the configuration management data that is developed and updated by the contractor, with inputs by by the Navy representative in the JPO. During this phase, and

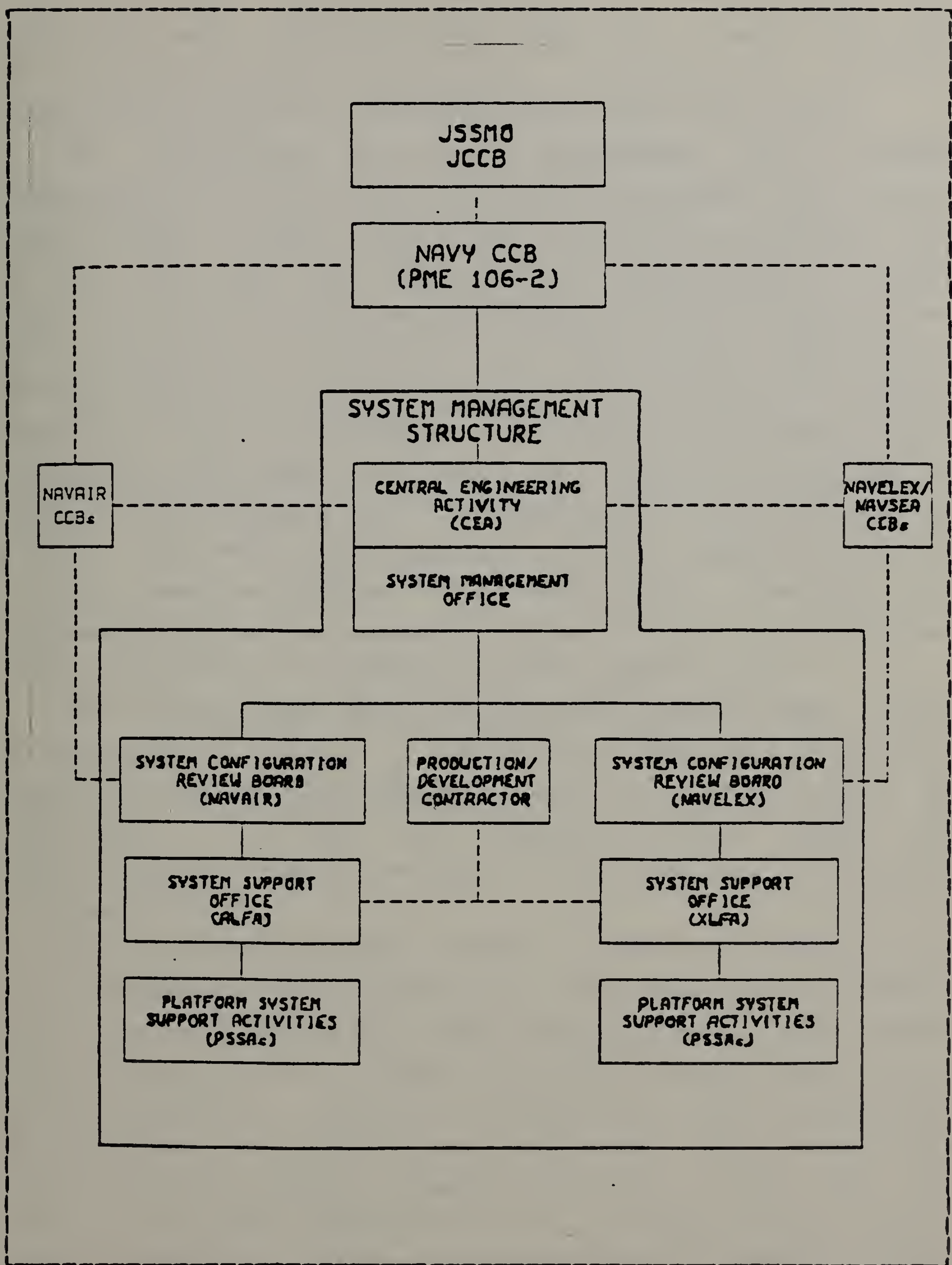
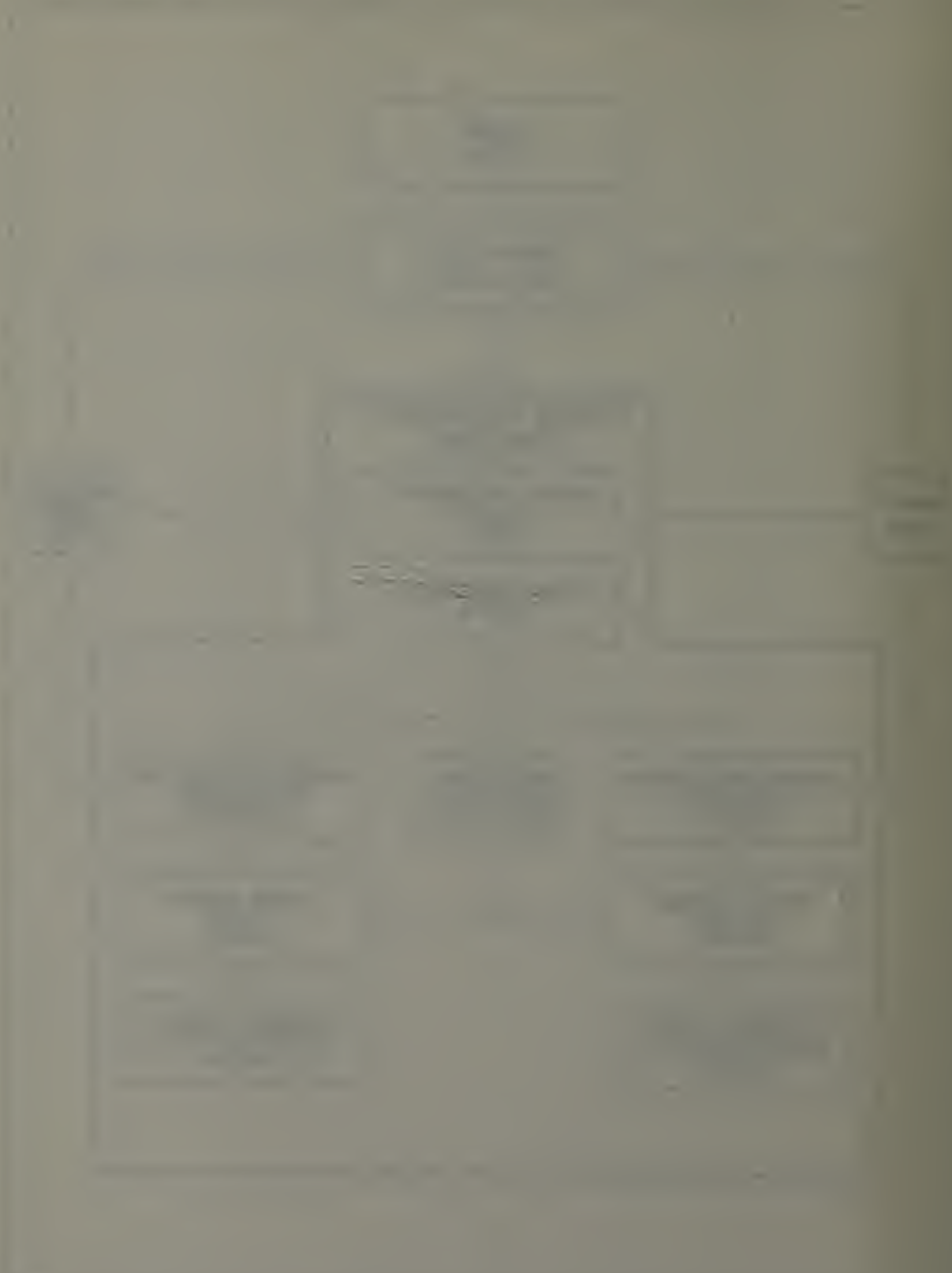


Figure 5.2 CONFIGURATION MANAGEMENT STRUCTURE.



after the NCCB and LFA CRBs have been established, the contractor will simultaneously submit all change proposals to the NCCB chairman and the JPO, who retains the approval/ disapproval authority throughout the transition phase.

The contractors production management plans require coordination with the JPO during the development and transitition phase. This coordination is made more difficult due to the fact that the contractor is working under a fixed price contract and any changes require contract negotiation. The contractors production plan along with the product configuration will become firm at the conclusion of development and prior to production of the GPS UE. The contractors production plan will influence the cost and the ease of incorporating changes into the design during the production period. The worst case planning concept implies the planning for numerous changes during this period. Therefore; to implement changes the production plan will have to be flexible and flexibility normally means a greater cost.

The support phase will coincide with the AF PMRT, which is scheduled for FY 87. During this phase all contractor change proposals affecting the Navy UE CIs/CPCIs will be submitted to the LFAs for inclusion on the agenda and presentation at the CRB meeting. This ECP flow is included in Figure 5.10.

The Navy configuration control management plans rely on the establishment of the NCCB and CRBs early in the transitition phase. Along with their establishment a data system must be established to accept the configuration data (i.e., product baseline) from the contractor. The data system should handle not only the Navy unique UE, but also the data interface with the DoD common UE items. This data will undergo continuous update during the transition and support phase. The data must be available and in useable form to facilitate the configuration control function. The Navy

needs to know exactly what items it has and what the configuration of each item is in real terms.

Planning the configuration management structure around the most complex case implies that the support facilities for configuration control be established to support the configuration control management of both hardware and software. To accomplish the configuration control of software, a minimum of three Navy Software Laboratories and two Land Base Test Sites must be established. This arrangement of labs is depicted in Figure 5.3. The software laboratories at XLFA and ALFA could be eliminated with the use of a dumb FMI. The software laboratory at the CEA will be necessary under either concept to allow for centralized management and first order impact studies of ECPs. The pivotal roles in the management structure are the roles played by CEA, XLFA and ALFA.

1. Central Engineering Activity (CEA)

The CEA acts as the NAVELEX SYSCOM technical agent for in-service engineering for the GPS system. As such, the CEA supports PME 106-2 in ensuring that the GPS UE remains continually effective and in combat ready state for fleet use as long as it is part of the Navy inventory. CEA will provide the central configuration control management function for the Navy GPS UE.

It is the opinion of the researchers that the distribution of UEs throughout the Navy, as well as the broad interest in utilizing the mission advantages that GPS can provide, will result in a continuing stream of hardware and software changes. The largest amount will be software changes, because the GPS is approxiamately 80% software. These inputs will get to the CEA through various media. Inputs from the fleet activities and the SYSCOMs will be routed via the respective LFA to the CEA.

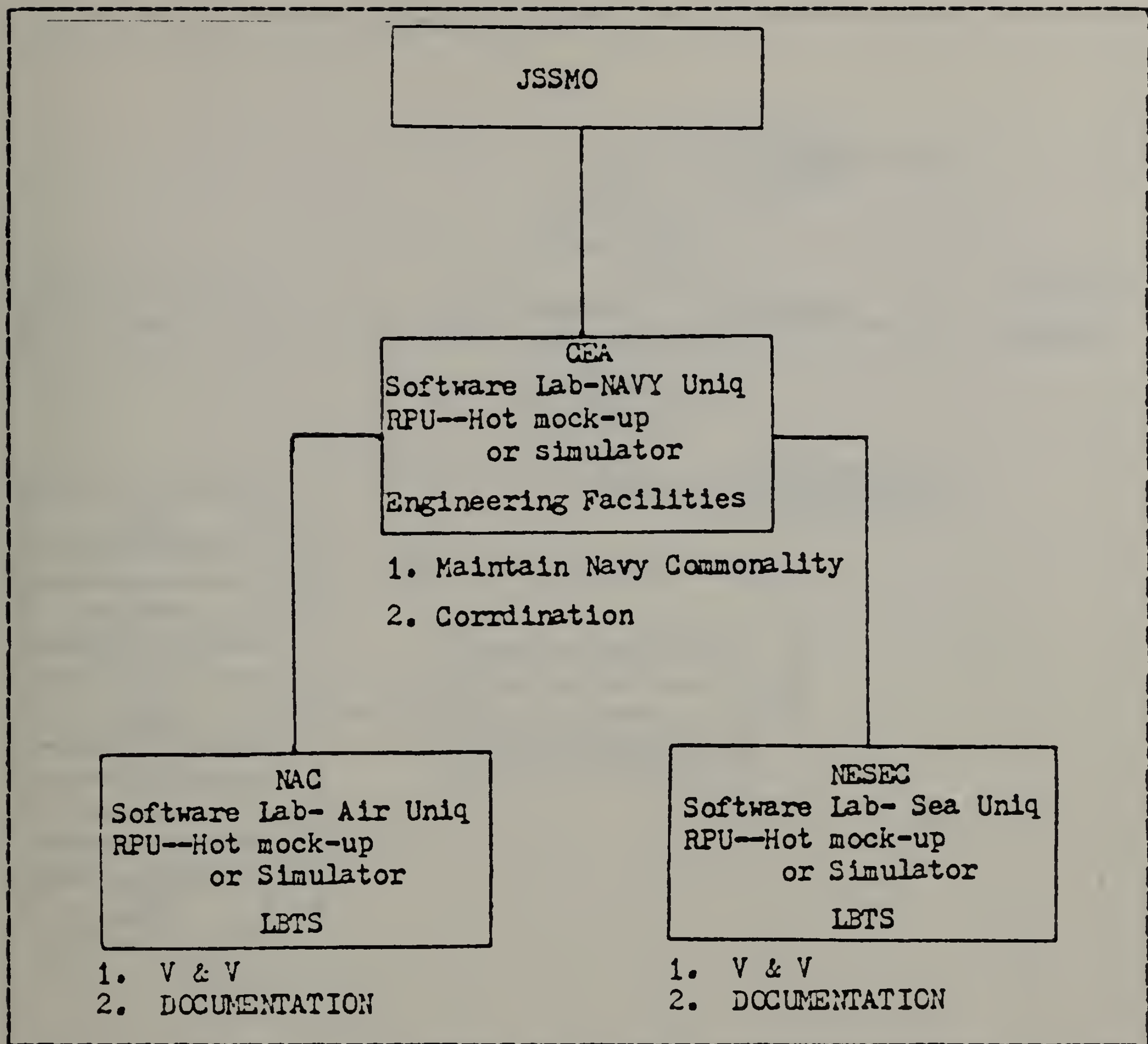


Figure 5.3 SOFTWARE LABS/LAND BASE TEST SITES.

Information will be consolidated by an initial screening group that will review all incoming data and summarize/categorize problems, issues, etc. in a concise format. These summaries will be grouped into three categories for assessment and response. [Ref. 31]

1. DOD COMMON/NAVY COMMON
2. DOD COMMON
3. NAVY AIR/SEA UNIQUE

This process is graphically displayed in Figure 5.4.

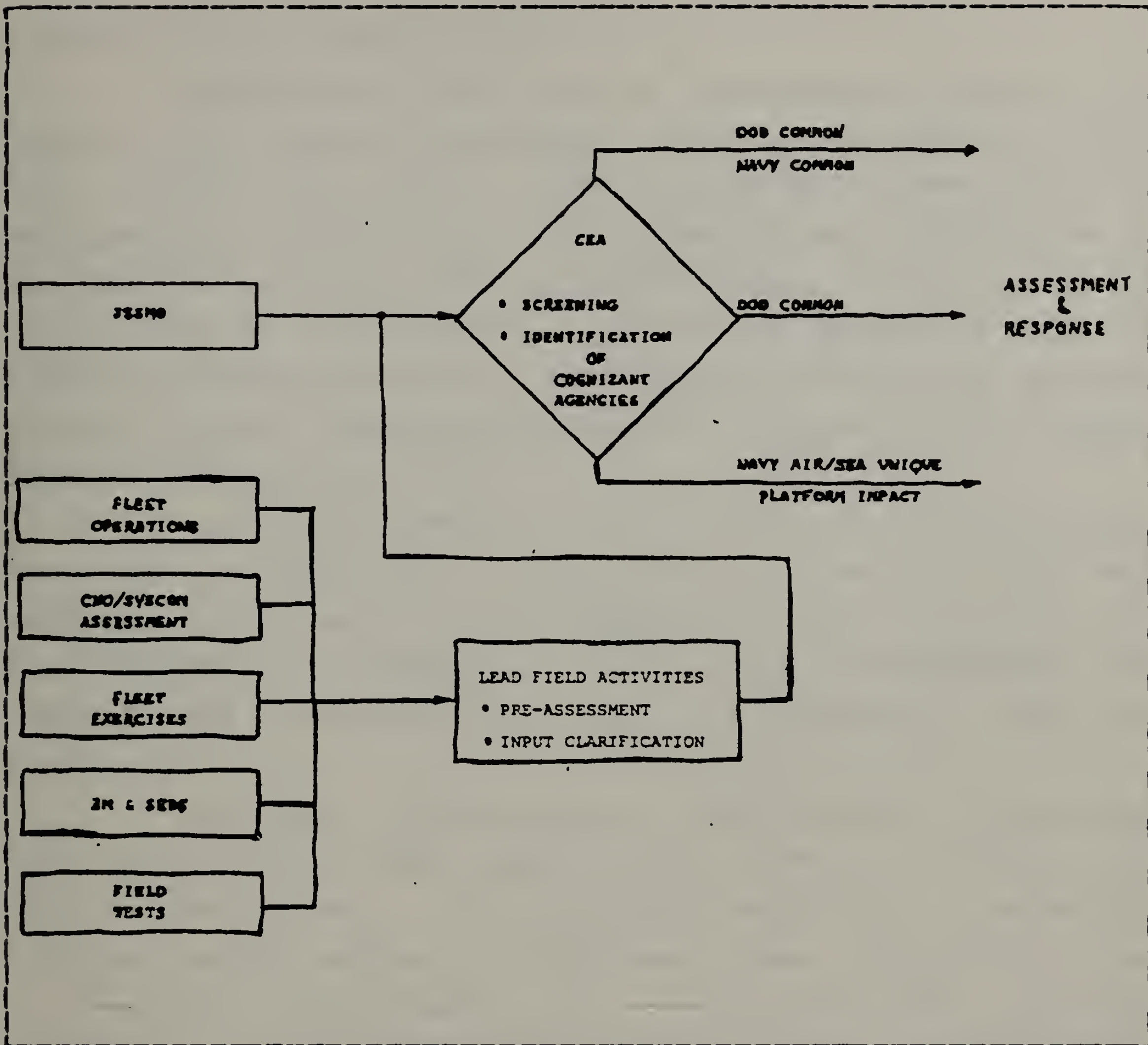
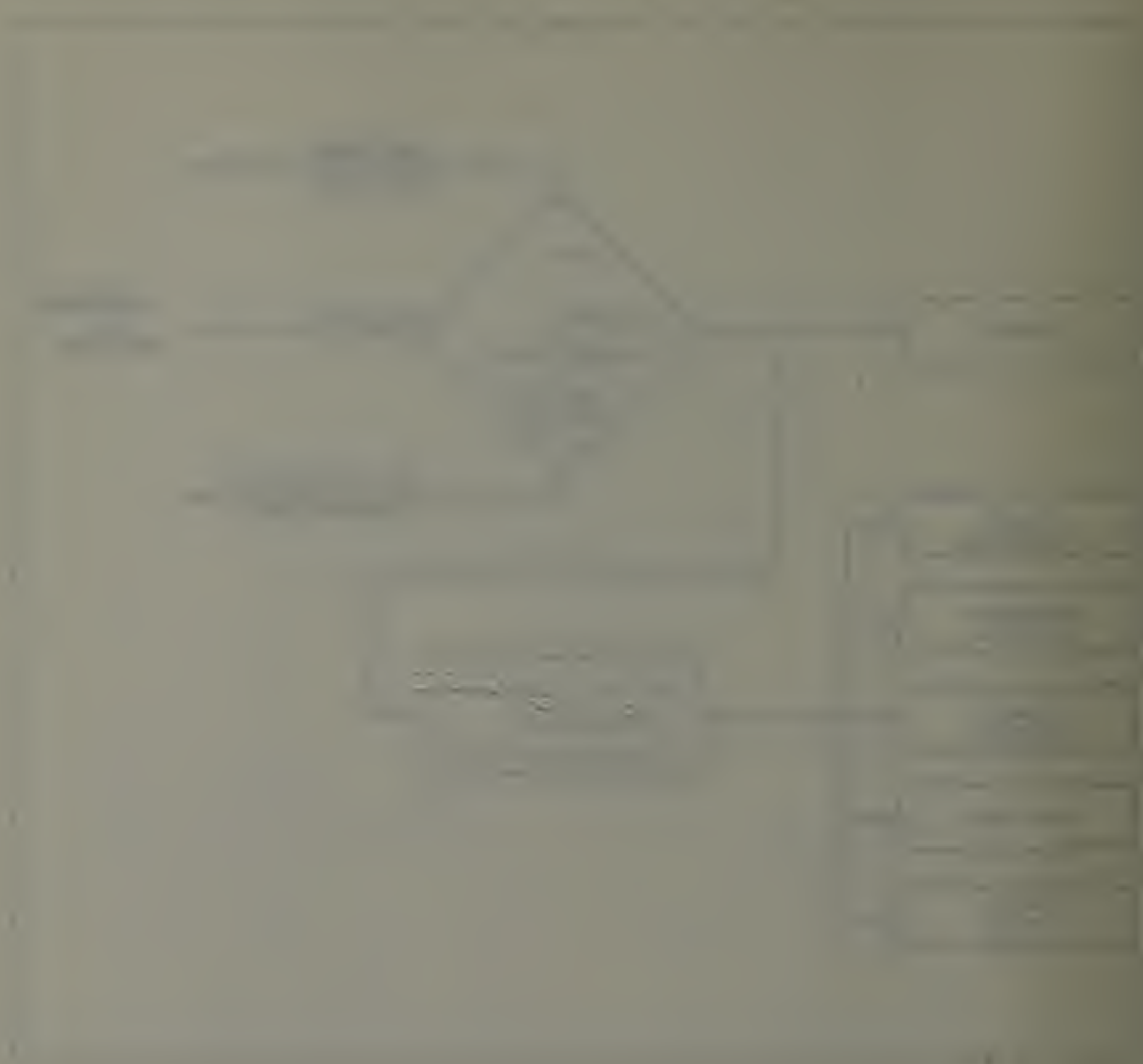


Figure 5.4 INPUTS TO CEA.

Each of the CEA engineering sections and SYSCOM component units, working in coordination with each other will determine problem definitions, solutions, specification to implement new requirements, objectives to deal with technical issues, system enhancements to utilize technological advancements, work packages for integration and recommendation on ECPs received. The coordination of this effort is very difficult and is crucial to the commonality objective.



Written statements of agreement should be developed to implement this coordination.

Analyses and tests will be performed to isolate the source of the reported problems. Problems related to platform systems or within JSSMO cognizant items will be examined in coordination with personnel and facilities of the SYSCOMs and the JSSMO, respectively. Having isolated the source of the problem, alternate solutions will be explored through analysis. The approach taken will be coordinated by the appropriate Project Engineer with tasking approval through the CEA.

The full complement of CEA, JSSMO and SYSCOM facilities will be utilized to determine the best fix for each problem. Solutions will be examined through laboratory and platform tests, as required. Test reports summarizing test results and recommendations for implementation will be prepared.

New system requirements, technological issues and ECPs received from PFAs stemming from fleet utilization, new mission needs, etc. will first be evaluated to determine alternative approaches to implement these capabilities and to identify their impact on the UE and other platform systems. It is recognized as these inputs are evaluated, that the implementation integration of all these new requirements will require close coordination and interplay with all agencies involved. This should be handled through a PrePlanned Product Improvement agreement. The product of these efforts will be a unified response and result in specification changes, readiness improvements, platform integration packages or ECPs. Each will be accompanied by a detailed implementation plan which will ensure that the total program impact of each change has been accounted for. Where JSSMO cognizant UE are involved, a coordinated plan will be prepared to be sent to the JSSMO. [Ref. 32]

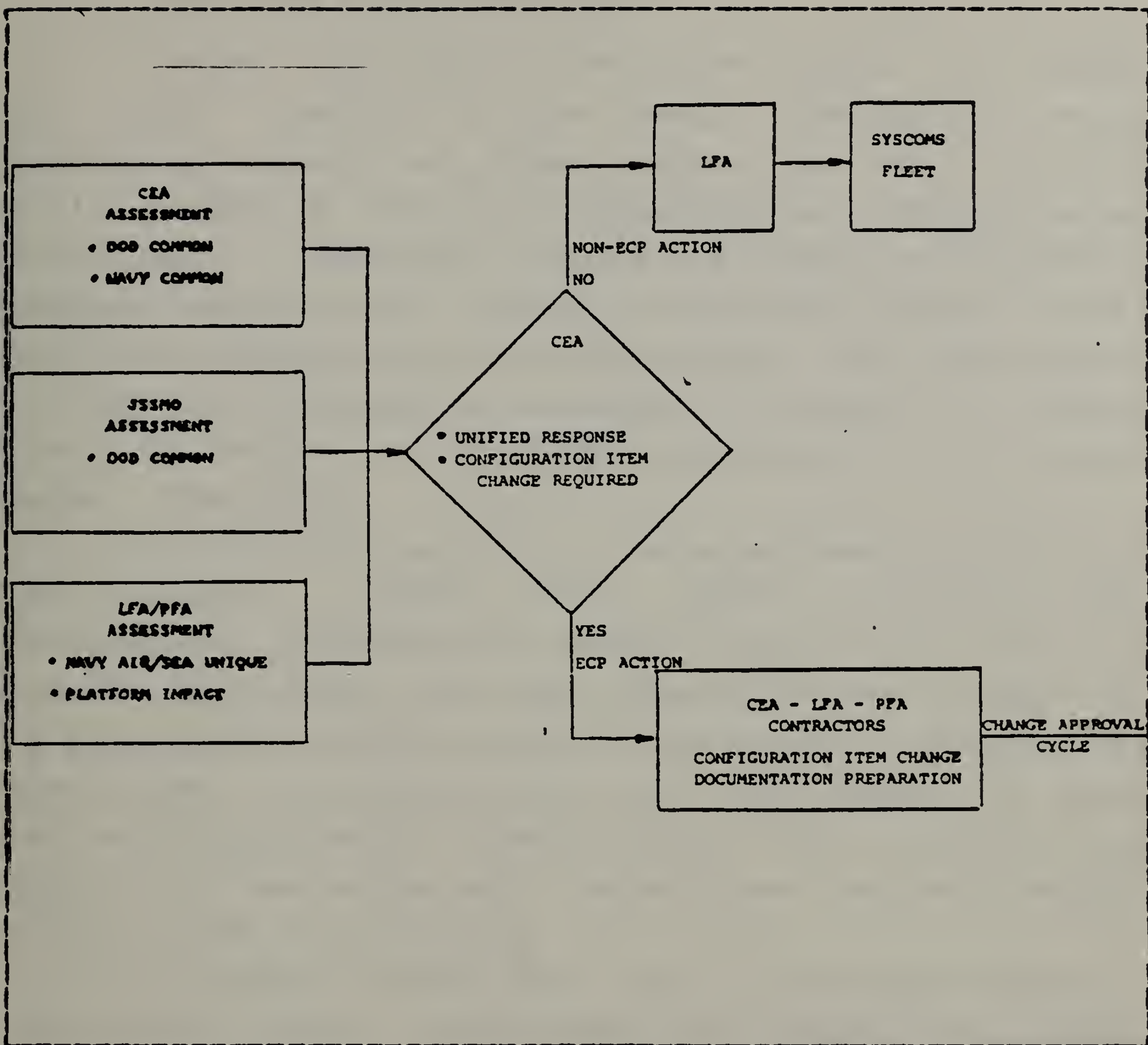


Figure 5.5 ASSESSMENT AND RESPONSE.

To fulfill the central management function and maintain the Navy commonality of GPS UE, CEA must coordinate the inputs form the SYSCOMs and the LFAs. This coordination will allow for a unified response to the Navy Configuration Control Board (NCCB) and ensure the commonality of the GPS system is maintained within the Navy.

2. Navy Lead Field Activities

The two LFAs for the Navy GPS program are NAVELEX LFA (XLFA) located at the Naval Electronic Systems Engineering Center, San Diego (NESEC) and the NAVAIR LFA (ALFA) located at the Naval Avionics Center, Indianapolis, Indiana (NAC). NESEC will perform the central configuration management function for NAVSEA, which will consist of all shipboard applications of the GPS system. NAC will perform the central configuration management function for NAVAIR, which will consist of all airborne applications of the GPS system. [Ref. 33]

The XLFA and ALFA will provide engineering and technical support, perform fleet support activity (FSA) functions and configuration control functions for both the hardware and software for their respective Navy unique UE. The management structure shown in Figure 5.2 indicates the direct lines of communications that are required to unify the Navy configuration control effort and to update and support the Navy unique GPS hardware and software through the life-cycle of the system.

An element of the LFAs will be the support integration activity (SIA) for the Navy GPS integration program. The primary function of the SIA is to provide follow-on engineering services during DT&E to support the development of the PMIs during Phase III. The LFAs will identify and control the configuration (hardware/software) for the GPS UE platform interface (PMI). this will be a coordinated effort with CEA as the pivotal point of intraservice coordination.

A Land Based Test Site (LBTS) will be established at the LFAs to support the GPS integration program and software/hardware changes through the life-cycle phases of the GPS program. An extensive software repository including firmware, verification and burn-in functions for the Navy

platforms/ GPS interfaces and the Master Program files for the system FMIs will reside at the LBTS. [Ref. 34] The LBTS will include a software laboratory to perform the necessary functions for processing software changes.

Located at both LFAs, will be a Configuration Review Board (CRB) to review and evaluate all changes to the Navy GPS UE and assess the impact of the changes in their respective areas of expertise. A recommended composition of the CRB is shown in Figure 5.6. [Ref. 35]

The CRB has no final approval/disapproval authority for ECPs. It will review the ECPs and submit them along with their assessments and recommendations to the CEA for evaluation and forwarding to the SYSCOM CCBs and the NCCB for approval/disapproval.

A large task for the LFAs will be coordination of the PSSAs; however this must be done to unify the Navy in a manner that will allow for maintaining commonality along with an accurate product baseline. The Navy PSSAs are the field activities responsible for maintenance of systems resident on platforms that are interfaced with the GPS system. The PSSA will be responsible for conducting certification of GPS configuration changes to ensure compatibility with interfaced systems. The functions that must be performed by the PSSA are as follows: [Ref. 36]

1. Review and coordinate the analysis of all platform problem reports and all proposed changes that impact the GPS system with the appropriate LFA.
2. Ensure that all platform system problems and proposed system changes related to the GPS system are analyzed for impact upon GPS UE. Whenever an impact on GPS UE is identified, the engineering data of the changes are submitted to, and coordinated with the appropriate LFA.

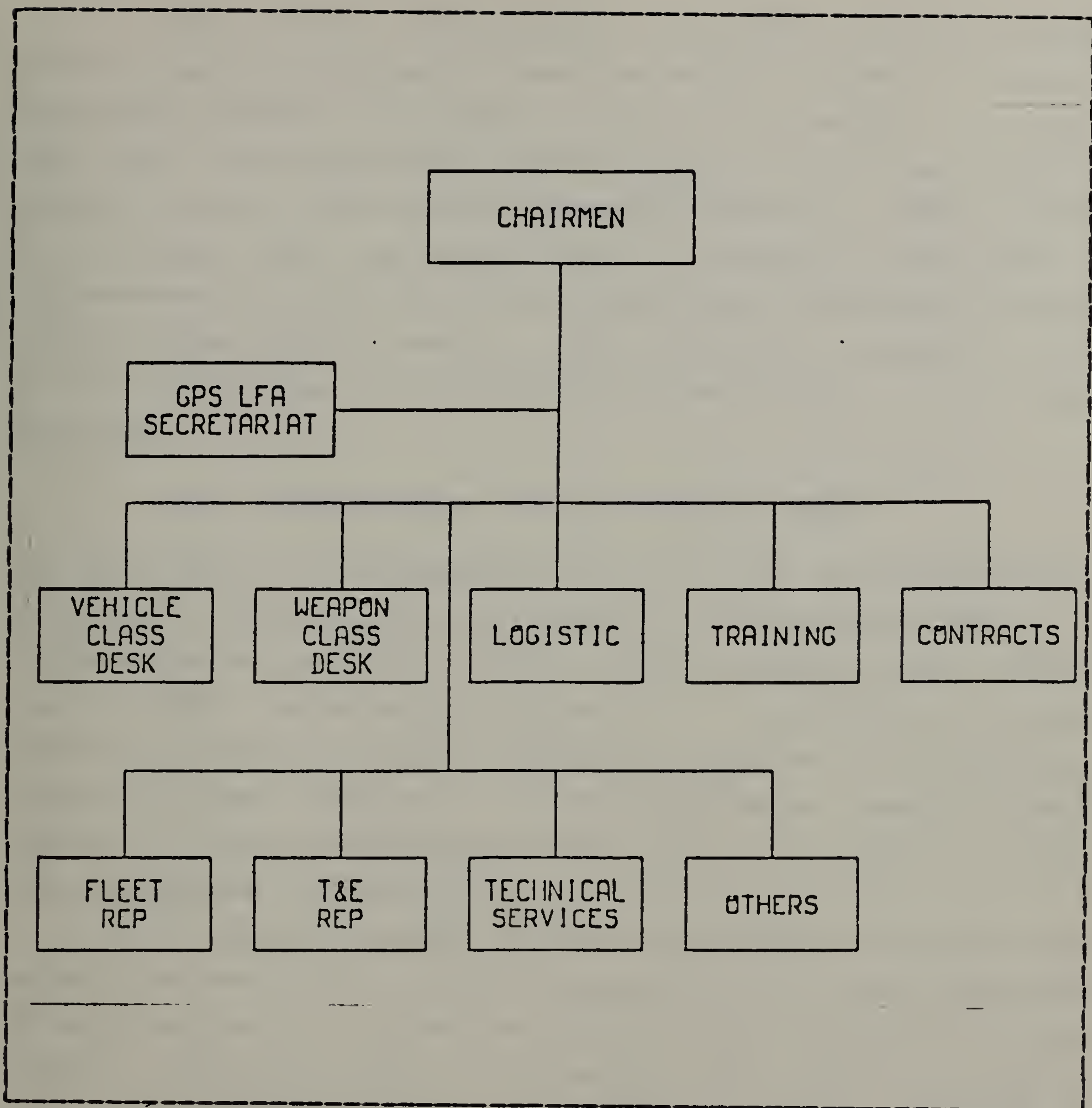
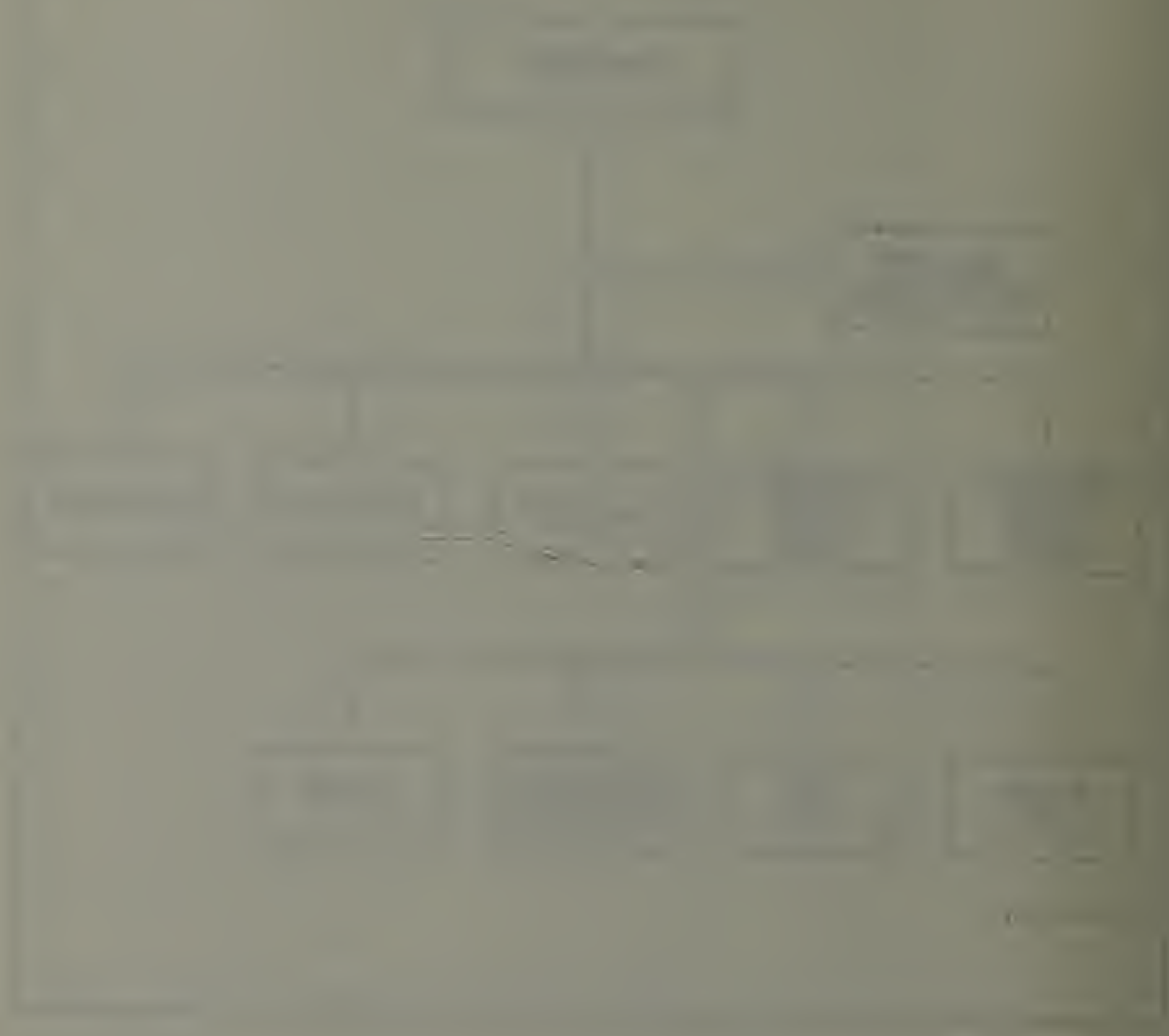


Figure 5.6 CONFIGURATION REVIEW BOARD.

3. Perform the certification of GPS UE changes that affect the interface characteristics and functions of the related FMI unit.
4. Participate on the CRBs as required.



Due to the organization structure of the NAVAIR PSSAs a major coordination problem exists for NAC. Working agreements should be sought as soon as possible to ensure that ALFA is established as the central and lead control agency and that the single interface between ALFA and CEA is the one that is established. Without this type of arrangement the proliferation of different CIs/CPCIs between NAVAIR PSSAs could result. This would run counter to the stated objective of maintaining commonality in the GPS program.

3. Navy Configuration Control Board (NCCB)

The NCCB will be responsible for the Navy UE configuration management through the life-cycle of GPS [Ref. 37]. A recommended composition of the Navy Configuration Control Board (NCCB) is shown in Figure 5.7. The NCCB will review proposed ECPs and provide technical approval or disapproval based on these reviews. It will determine overall system impact of the proposed change and assure that the ECP covers all subsystems affected.

It is the opinion of the reasearcher that the NCCB should be chartered with the authority for final approval/ disapproval of all ECPs that affect Navy unique UE CIs and CPCIs. For these ECPs an information copy should be sent to the Joint Configuration Control Board (JCCB) located at JSSMO for update of the central overall system configuration data file.

C. ECP FLOW FOR NAVY UE

All proposed changes to the system will be classified with regard to their total impact on the GPS system, existing documentation, and cost effectiveness. Change classifications and justification codes will be in accor-

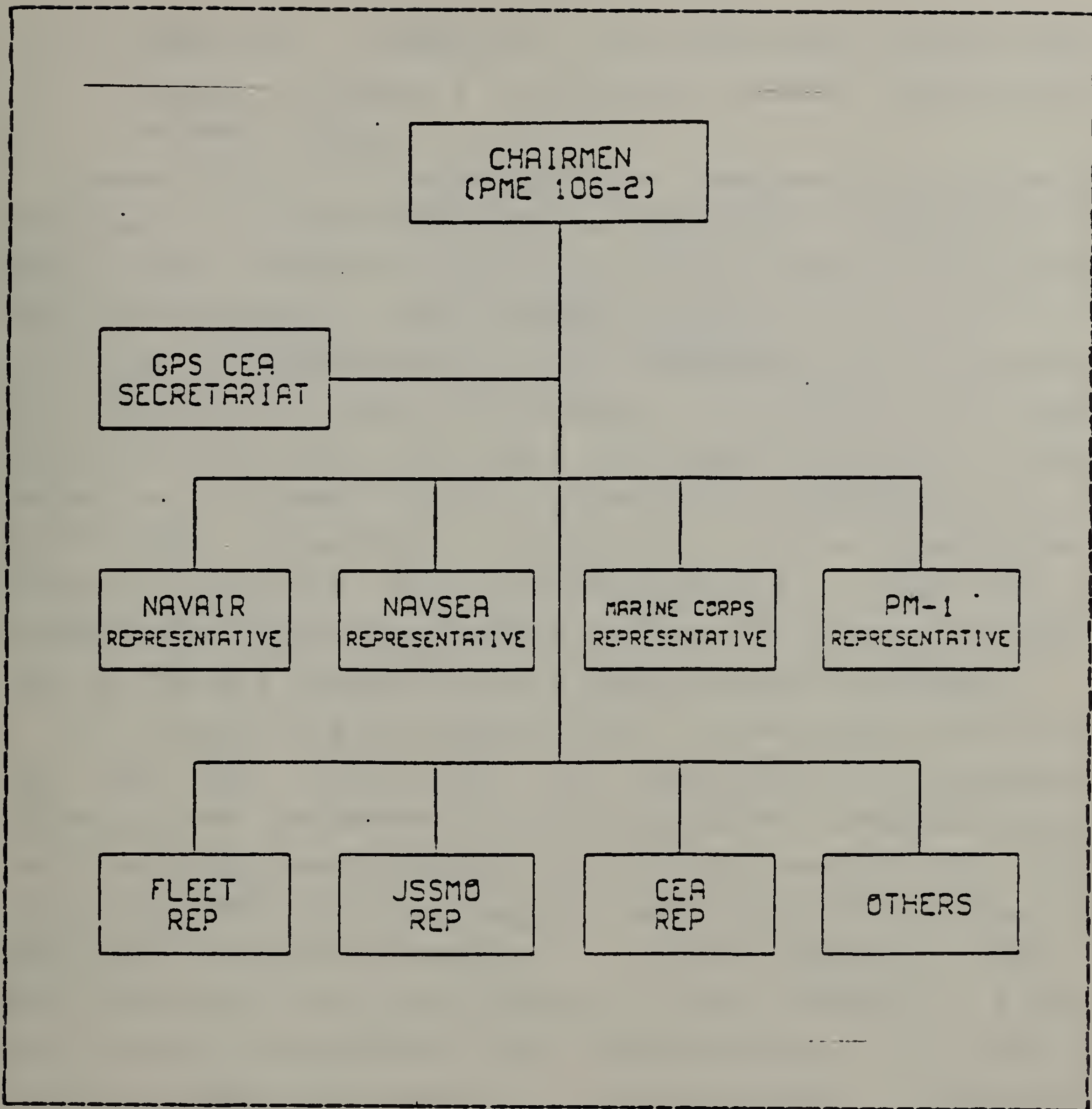


Figure 5.7 NAVY CONFIGURATION CONTROL BOARD.

dance with DOD-STD-480A as outlined in appendix C and D. Proper classification ensures ECPs will be adequately reviewed. Class I changes are further identified as to A or B in accordance with the following: [Ref. 38]

1. CLASS IA: A change to the operational system which requires a conjunctive system software and hardware change.

2. CLASS IB: A change to the operational system which does not require a conjunctive system software and hardware change

Class IA and IB changes will be assigned priorities in accordance with DOD-STD-480A as described in appendix E. The priority assigned will be the major factor determining the time required to fully process the ECP.

It is the contention of the researchers that the ECPs will mainly fall under the priority of routine with a few exceptions that will fall under the urgent priority. This contention is based on the researchers interpretation of Mil-Std-480A (Appendix C through E) and the operational aspects of the GPS as a navigational aid. This can be accomplished through the design of the FMI and the integration of the GPS system into the weapon system platforms.

It follows from the above that if the major portion of the ECPs are routine then the configuration management structure and documentation flow should be designed around the time requirements and priority of the routine ECP. The few Urgent ECPs could be flagged and expedited on a case by case basis through the system. A major impact of routine ECPs would be in the utilization of block changes. A time table could be established for implementation of the ECPs as one block change (for example a yearly basis). This would allow for the collection of ECPs and the most effective use of a change. Using this method one block change could solve a number of problems.

A decision to process ECPs in this manner would allow for a stable production plan for the contractor and a firm planning horizon for the retrofit modifications to operational FMIs. The ECP flow through the configuration control management structure is depicted in Figures 5.8--5.10.

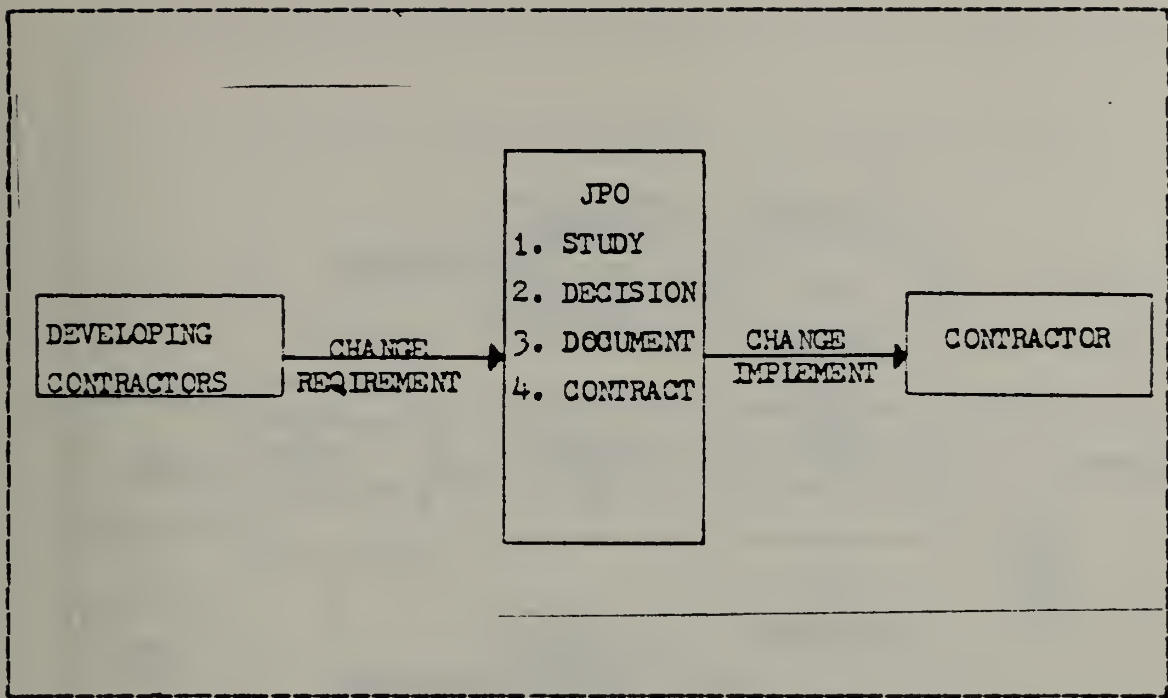


Figure 5.8 DEVELOPMENT PHASE.

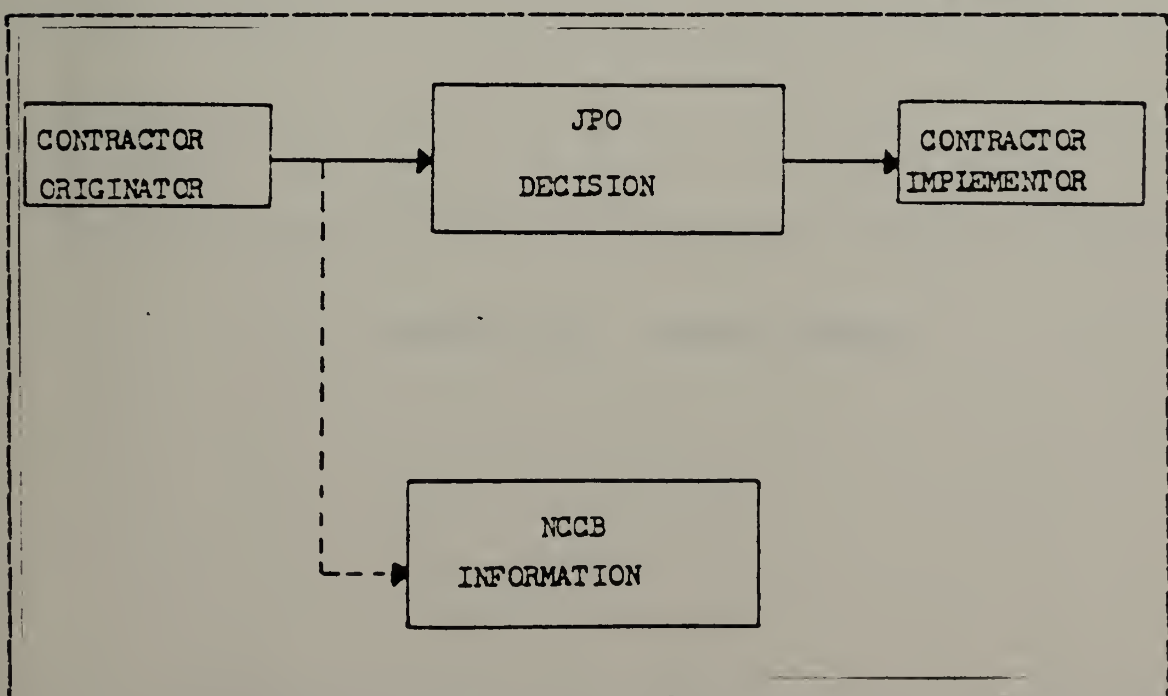


Figure 5.9 TRANSITION PHASE.

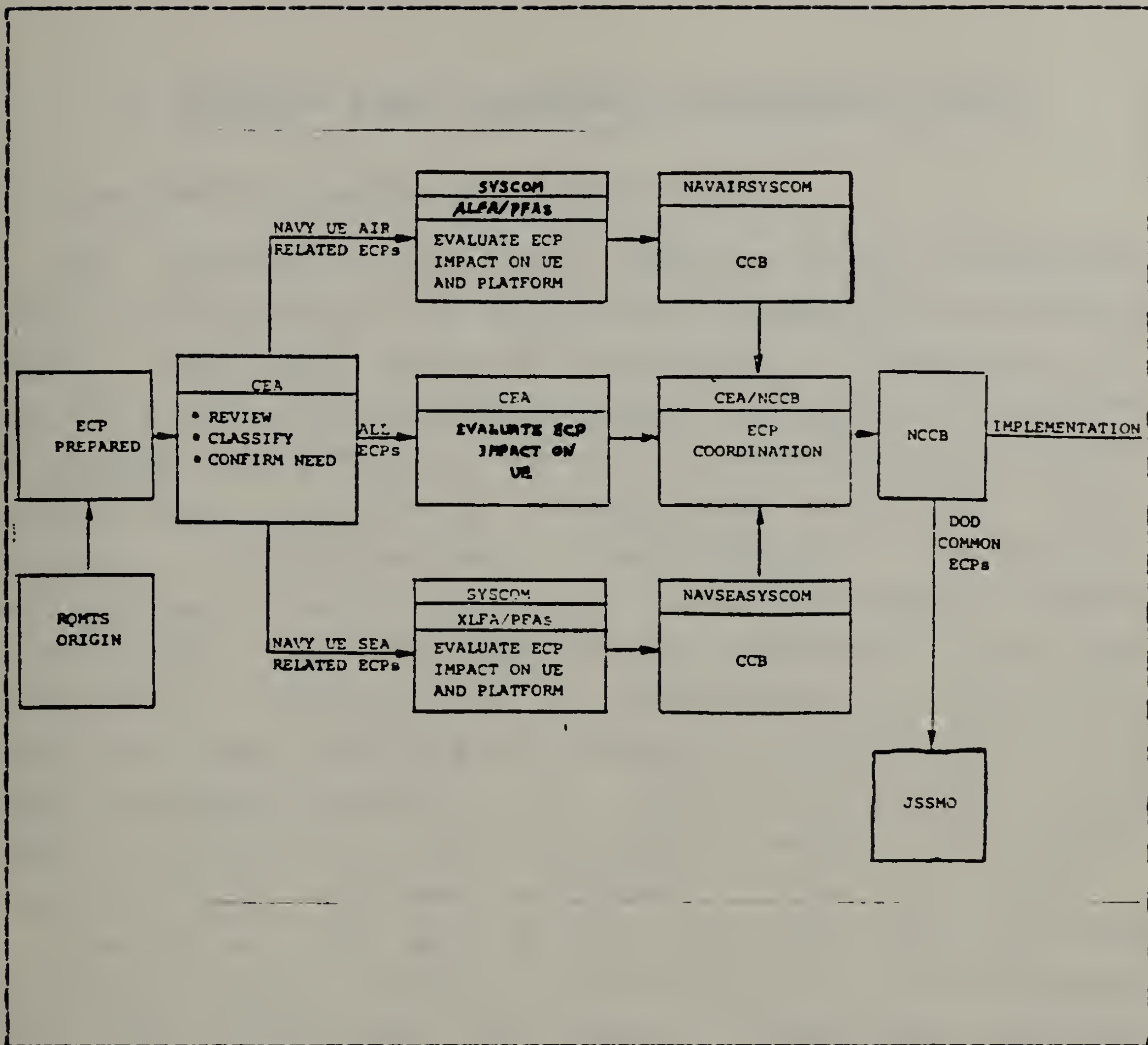


Figure 5.10 SUPPORT PHASE.

VI. COMPUTER BASED MANAGEMENT INFORMATION SYSTEM

A. COMPUTER DATA BASED MIS A TOOL FOR CM

GPS presents a very large problem in the management arena of coordinating the various and diversified management areas. The JSSMO, as stated previously, is responsible for the total DoD acquisition/engineering management of the GPS UE program after PMRT in FY 87. Responsibilites include configuration management, acquisition logistics, engineering, specification, acquisition, cataloging, provisioning, maintenance and inter-servicing, spares requirements, budgeting and funding management, financial management, training and UE installation. The three services; Navy, Army and Air Force, are responsible for the above management areas for the service unique items. With NATO and other agency use of GPS UE the scope of the coordination and data management problems is indeed very large.

Coupled with the above is the fact that there are three GPS sets; single channel, dual channel and five channel, that make up the GPS UE family. These sets will be installed on various platforms bringing almost all areas of each service into the coordination and data management problem. Commonality among the different sets, which is accomplished through the use of common SRUs with common CPCIs, and the commonality within the sets across various platforms is a stated objective of the GPS program. In order to maintain this commonality and effectively manage the GPS resources the management activities need to be centralized. To support the JSSMO, Navy, Army and Air Force in centralizing the management activities and to provide the necessary in-house engineering support for the GPS UE

program, an on-line real-time computer based management information system (MIS) is required. This system can then provide the "TOOL" to manage and control the UE support elements contributing to the LCC throughout the GPS program life cycle.

The idea of a computer based information system for the configuration management of GPS UE is not foreign to the GPS program. Lt. Thomas Abrahamson attended a briefing at Robins AFB on 25 January 1983 and Lt. Gerard Mauer attended a briefing at the JPO on 1 February 1983. Both briefings were conducted by Mr. John Fenstermacher, who is the Navy Deputy System Manager and the UE Program Manager for JSSMO. The briefings dealt with the subject of a computer based MIS, as a tool for configuration management. Chapter six is devoted to taking a look at a computer based MIS that could be used as a tool for management and control. The observations and conclusions presented in this chapter are based on the researchers understanding and interpations of the information presented at the two briefings.

The coordination of the GPS UE program relies heavily on effectively handling the massive data requirements generated for support of system engineering. The management information system must be centered around making changes to a design (i.e., ECPs) and the monitoring of the impact of these changes to the product baseline. The biggest problem in the past has been the tracing of a problem from generation by the fleet or a user activity through its resolution, and all changes that take place until it comes out the door as a mod-kit to solve the problem.

An on-line real-time computer based MIS utilizing distributive processing will have as its primary function the support of the centralized management activities by identifying, scheduling, controlling, auditing, reviewing, accounting, processing and inter-relating a life cycle flow

of the following support data related to controlling the GPS UE baseline:

1. ECP TRACKING AND MANAGEMENT DATA (the central core)
2. INVENTORY/CONFIGURATION STATUS ACCOUNTING DATA
3. ITEM PROCUREMENT/SUPPORT DATA
4. COMPUTER RESOURCES SUPPORT DATA
5. BUDGET/LIFE CYCLE SUPPORT COST DATA
6. LSA MODELING SUPPORT DATA
7. PROGRAM SCHEDULING/PLANNING DATA
8. FLEET READINESS MANAGEMENT DATA
9. DISCREPANCY/SERVICE REPORT DATA
10. MINUTES/ACTION ITEM REPORTING DATA

The data base required to operate this system would be built during the transition phase, which would include the product baseline and all other contractor and test data. This would put the MIS fully operational at the begining of the organic support phase of the GPS UE program.

The data base system would be divided into three major sections and operated on a distributive bases, as shown in Figure 6.1.

1. <u>INPUT/FILE MAINTENANCE SECTION</u>: This section is composed of on-line data entry, file maintenance, data/ file, monitoring of all support data work files processed/generated by the assigned support engineers, data entry, and data based administrators. The data in this section is in a changing mode and provides a mirror image of the master data base.
2. <u>INQUIRY DATA BASE INFORMATION MANAGEMENT SECTION</u>: This section is composed of the master data bases retaining current support data information generated from the work files. This section is used primarily as a management tool for data base administrators, and program managers as an on-line inquiry/ information management system. This is an interactive system with only read data.

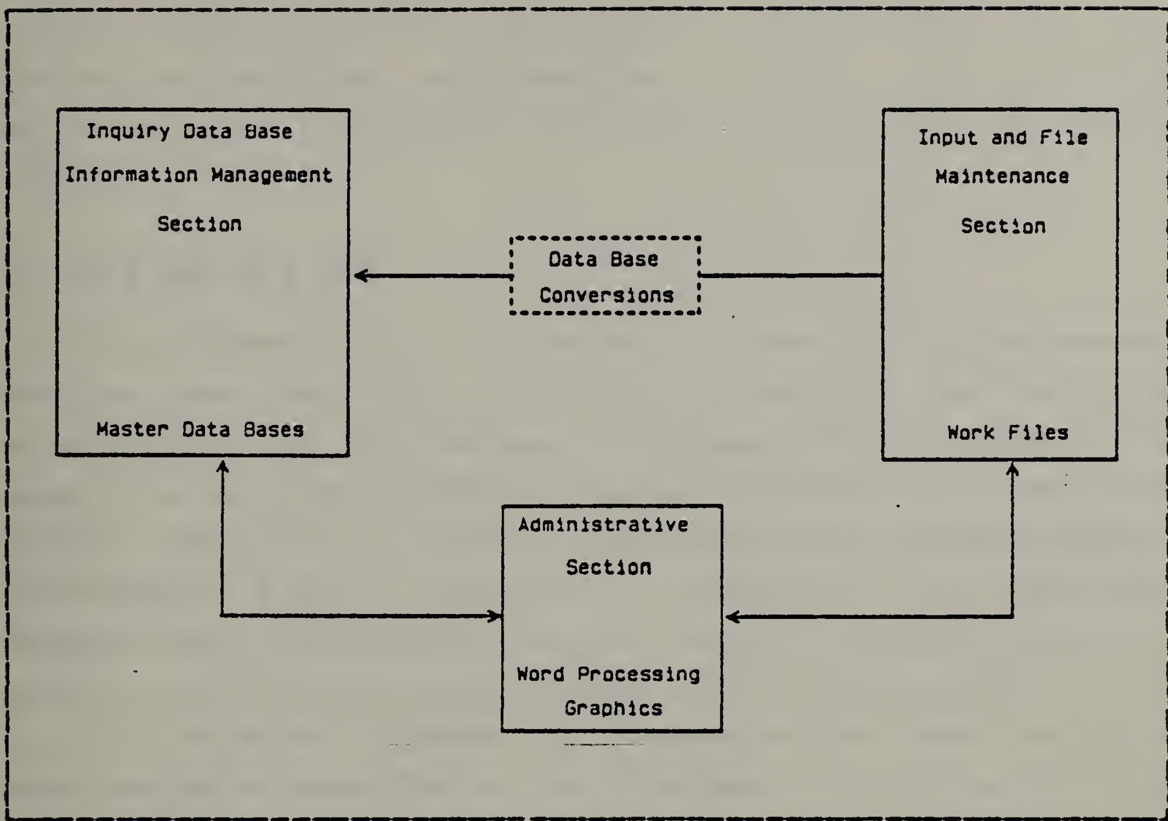
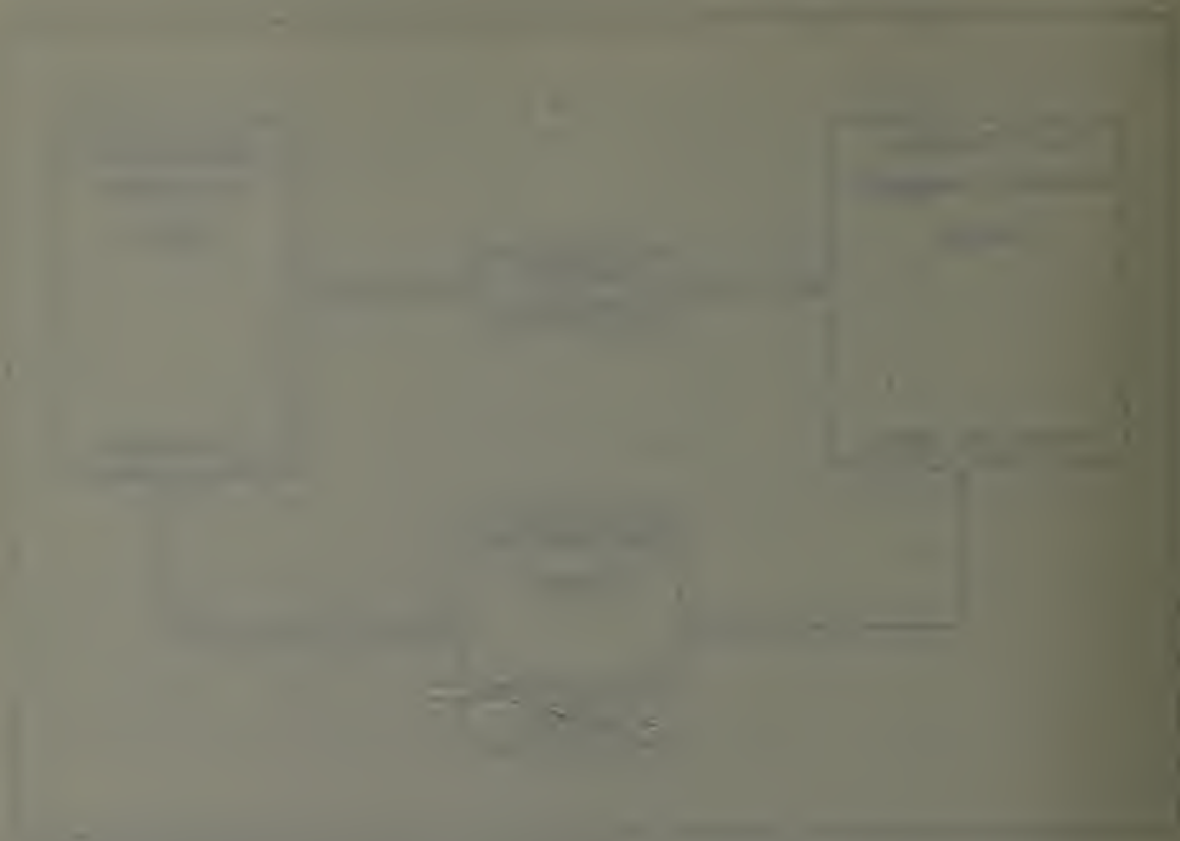


Figure 6.1 SECTION OVERVIEW.

3. ADMINISTRATIVE SECTION: This section is composed of:
   a) Simplified inter-office word processing system for office letters, memos, and etc.
   b) Document word processing system for large documents requiring independent controlling of document data.
   c) Graphics section for generating management graphic illustrations for scheduling, planning, and etc.

The modern day computer puts the capability of such a MIS at our disposal. The major item will be the development and maintenance of the software to operate a real time interactive, distributive data based processing system. The existence of cross country telecommunication networks allows



for the centralization of this system at the JSSMO, with remote terminals and time sharing capabilities for the respective Services and agencies. Thus; the technology exists for the utilization of this configuration management tool.

B. MIS AND THE ECP

The inter-activity of the data bases will allow management to use "WHAT IF" drills in determining and reviewing solutions to GPS UE problems. Proposed ECP solutions can be input and an impact study can be accomplished on a real time basis, along with a LSA in accordance with MIL-STD-1388-1. Therefore; when a solution is generated the inventory, support and LCC impacts can be readily obtained prior to putting the solution into effect. This would allow the use of an iterative process to determine the best solution considering trade-offs to the problem. With the GPS sets being 80% software the tracking of software changes can be accomplished, along with the impact study of each software change. When a computer program change is required the system identifies that change to the new CPCI. The software change is then linked to the firmware part number (chip), which is further linked to the SRU that chip is on. Therefore; management would know the SRU effected the chip and the computer programs that are on that chip. This becomes especially important when dealing with interface compatability between DoD common and Service unique.

Each ECP generates a record for the problem. This record remains active until the ECP is closed out with a mod-kit installation. The record is kept for historical data. Working on the concept of block changes this aspect allows management to monitor the changes and effectively coordinate them into a block change. This provides a

complete status tracking of each ECP throughout its review process and couples with the ECP the impact review of that change. Cutting across the ECPs allows for establishing the budgeting information required for the purchase and implementation of the block change. In order to keep the ECPs on schedule a comm log system would let each activity know if there is an action item for them in the system. Coupled with this a PERT network would show each activities review response date.

The computer based MIS would combine the inventory and configuration management system to accomplish asset accounting not only for DoD, but for each of the services. This system has the capability of telling management what the asset is, where it is located, its condition and compatability. Each platform creates a separate record for tracking the location of the LRUs and the SRUs. This allows also for the system to show the impact by platform.

C. MIS POTENTIAL PROBLEMS

The system discussed so far seems to be the dream tool for configuration control management of the GPS UE. However; certain areas appear to the researchers as potential problems requiring further research.

1. Data Security: The system to operate completely and effectively will require priviledged data and possibly classified data on file or accessable through other computer systems. Without the proper data security contractors could obtain priviledged data allowing them an unfair advantage in future GPS related contracts, and classified data could fall into the hands of the wrong people. What security measures can be taken to ensure only the people with the need and clearance can access this data? The use

of user identification codes and special coded files does not seem to fully answer this question.

2. <u>Quality Assurance of Input Data</u>: The potential problem is expressed by the old saying of garbage in garbage out. The system can provide some quality assurance through the use of data cross checking, this would eliminate the possibility of inputting incorrect part numbers, NSNs, or ECP numbers and etc. into the data base. The use of designated data base managers to review all inputs from each activity, will also provide some quality assurance. However; will this provide enough quality assurance to ensure an accurate up-to-date data base?

3. <u>Hardware Obsolescence</u>: Advances that are being made in computer technology, brings the hardware obsolescence problem into view. A possible solution to this problem would be for the government to purchase only the data based system software and lease the required hardware. This not only eliminates the hardware obsolesence problem but will also spread the cost of the hardware over more years. Centrally locating the computer system at the JSSMO with remote terminals on a time sharing basis, the problem of the diffusion of configuration management system software would be curtailed. The major question that must be answered in this area is does the benefit outweigh the cost of such a system?

4. <u>Configuration Control of Data Base Software</u>: The configuration control of the data base MIS software presents another potential problem. A configuration control board with members from each of the user communities would need to be established to review and coordinate changes required in the MIS software. Designing the MIS software in a modular format and

using high-level computer language will allow the necessary changes to be made in an efficient manner. The question still remains about who will chair such a board and who will make the final decision on the changes.

VII. SUMMARY

A. ANALYSIS OF THE OVERALL SYSTEM

As stated earlier, the primary objective, of the thesis, was to freeze the dynamic nature of the configuration management plans and examine the configuration control aspects of the plans. The risk that is taken by doing this is the implication that the configuration control management plans exist and will continue to exist as they are seen at this one point in time. The realistic picture is that everything is continually changing and these changes will impact configuration control. What freezing the plans in time does is to allow the researchers the opportunity to examine it and present a point estimate for comparison. Therefore, the problems and conclusions reflect the configuration control management plans at this point in time.

The configuration control management plans for the DoD common and the Navy unique CIs and CPCIs have all the required and necessary pieces to allow it to evolve into an effective and feasible plan for configuration control during organic support. The conception and plans to incorporate a computer based MIS as a configuration management tool shows perceptive insight into the importance and complexity of configuration control management for GPS UE. This tool also offers the ability to integrate not only configuration management among the different services, but also inventory and logistics support, which is necessary to provide a control system that will monitor the GPS UE in an efficient and effective manner.

To arrive at the overall conclusion that the configuration control management plans are managerially sound, the researchers looked for items that they felt were crucial. The first item was the baseline management concept. We found that a functional baseline existed in phase 1 and an allocated baseline exists during phase 2. Work is in progress to establish a product baseline for phase 3 and configuration control management plans will use the product baseline as its basis.

The researchers arrived at the conclusion that the management plans acknowledged the difference between hardware and software configuration control. The necessary support documentation and facilities for software configuration control were in the plans. The positive point here was that software changes were not looked on as maintenance, but were considered as design changes. The software concept is very important due to the fact that the GPS UE is approxiamately 80% software and this is the area seen as having the greatest potential for change. Thus, a majority of the costs associated with change proposals will result from software changes.

The other critical item was the management structure itself. The plans acknowledged the need for centralized management of configuration control to meet the objective of commonality. The researchers understood the plans to place the JSSMC as the central manager of DoD common UE and CEA as the central technical manager of Navy unique UE. The large number of agencies and platforms involved in the GPS program requires a centralized management structure. The Navy and the JSSMC have developed plans for the management structure that places control boards at the proper level to ensure regulation of the UE configuration.

The above elements lead the researchers to the conclusion that the prescribed configuration control management plans for GPS UE were sound. These elements are only the start of a good configuration control program and on their own will not evolve into an effective and feasible configuration control management system. Configuration control is not a fully automatic tool, it cannot be installed, programmed, switched on and left to run by itself. Like most tools, it will perform well only when used with skill, conscience, discretion and energy.

B. MAJOR PROBLEM

The major problem in the opinion of the researchers was that the different elements for configuration control were not integrated. In order to continue forward and develop the plans into a working solution we feel that written agreements of understanding must be developed and agreed upon by the major agencies. These agreements could then ensure that every agency was moving in the same direction in developing their plans for configuration control management. If the agencies are allowed to continue in an undirected environment, concerning configuration control, the objective of commonality will be lost not only in Service unique items, but also in the DoD common items.

C. RECOMMENDATIONS

Management attention must be focused on the development of written statements of agreement. These statements are required to establish the parameters and boundaries needed by the user agencies to bring their configuration control and integration management plans to maturity.

The following are recommendations that the researchers through their analysis have determined to be crucial to the GPS UE configuration control management plans. The list is not all inclusive, but represents a start, that we consider is in the right direction, for the evolution of the GPS UE configuration control plans into an efficient and effective configuration control system.

1. <u>Agency Boundary Agreements</u>

A statement of agreement should be developed that precisely identifies the boundaries for each agencys' area of responsibility and authority. An example would be to identify the boundary concerning changes affecting the interface between the RPU and the FMI. The Navy, for instance, would be limited to changes affecting host vehicle unique FMIs. Any recommended changes to the FMI that affect the RPU would be outside the Navy's boundary and would fall under JSSMO jurisdiction. What we mean is that no problem or enhancement of the host vehicle or service unique FMI should be allowed to ripple back through the RPU. Without this limit specifically identified, each service could theoretically make changes to their respective FMIs that also alter the respective RPU capabilities. The ultimate result would be a significant loss in commonality and an increase in the complexity of configuration control.

We recommend that any discrepancies or conflicts that affect interservice boundary responsibilities (for example, conflicts between the Navy and the Air Force) should be handled by the JPO prior to PMRT and the JSSMO after PMRT. Intraservice boundary disputes should be handled by their respective UE central management office, such as the CEA in the Navy. This would eliminate confusion between and within the Services concerning GPS UE boundaries. Providing specific keystone agencies in each

service to monitor and make decisions on the UE configuration control boundaries would help facilitate configuration control management.

2. Centralized Management Agreements

The key to configuration control management is a centralized management structure. All DoD common UE will fall under the central management of the JSSMO. The Navy central technical management should be placed at CEA with NAC representing the NAVAIR platforms and NESEC San Diego representing the NAVSEA platforms. This type of a management structure is essential in maintaining the commonality objective and should be stated in writing as a statement of agreement between the Naval SYSCOMs, CEA and the IFAs. Without a statement of agreement, coordination will be almost impossible. The coordination at this level is very important in maintaining control of the ECPs and obtaining the commonality objective.

3. GPS Integration Agreements

A firm integration plan for the Navy is needed immediately to allow the configuration control plans to evolve into a workable system. An integration concept statement of agreement should be developed. GPS is a navigational aid that can provide the host vehicle with very accurate position, velocity and time. What we mean by a navigational aid only can be seen best by an example. The example we will use is the integration of GPS into a high performance aircraft with an INS system. The GPS would interface only with the INS and act as an inflight calibrator for the INS. Thus; the GPS data is fed to the INS and the INS in turn interfaces the rest of the sensors, which it already does. This type of integration would allow for simplification of the design (mainly software), limit

integration problems and still utilize the highly accurate position, velocity and time data of GPS. This should be the strategy followed for integration. GPS should be used as the basic navigation aid among user platforms and electronically tied into the present host vehicles navigation systems to permit continuous updating of the navigational plot.

The concept of integrating GPS into numerous sensors and feeding data back and forth has created the effect of increasing the complexity of the design and configuration management. In order to develop a cohesive integration plan top down management direction is required. PME-106-2 decisions for the Navy, with JPO concurrence, via CEA and through the LFAs should be made at this time to produce the necessary guidelines for the Navy platform managers, who must be the integration planners for their respective platforms. We feel that a decision to integrate GPS as a navigational aid only and not as a "do everything" system would allow for effective integration plans. Preplanned product improvement would be used to allow for future expansion and integration of the GPS system into updates of present weapon systems and subsequent new platforms. We see this as a natural extension of the GPS utilization after the initial system integration problems are resolved and its full capabilities are understood by the user agencies.

4. ECP Tracking Agreements (During Testing)

Management attention needs to be focused on developing a system to track and monitor all changes during the testing of the GPS UE. This requires a statement of agreement between the contractors and the JPO that states exactly how the changes will be tracked and monitored during DT&E and ICT&E. If these changes are not tracked and monitored, the required product baseline for configuration control will not be available at the end of the testing period. The

major problem exists during the overlap of DT&E and OT&E. Needless to say, without this product baseline there can be no effective configuration control management.

5. Routine Block Change Agreements

An agreement should be developed, among all the involved agencies, that adopts the block change concept and establishes a time table for block change implementation. Integrating the GPS UE into the weapon system platforms as a navigational aid should result in the majority of the ECPs being routine priority. This would reduce the amount of contract negotiation required to implement the changes during production and allow for scheduled planning of retrofit modifications to the UE in operation. If this statement is not developed and accepted the control and timing of ECPs will be seriously effected. Thus, creating the need for a more complex configuration control management system, which will escalate the system's operating costs.

6. Navy Software Laboratory Agreements

A written statement of agreement should be developed among the three Navy Software Laboratories. This agreement should define each laboratory's area of responsibility and its interface with the other laboratories. As stated in chapter five the two software laboratories at the LFAs could be eliminated with the use of a "dumb" FMI. However, it is the opinion of the researchers that to maximize commonality and to give the FMI the ability to effectively utilize and incorporate preplanned product improvement a FMI that lies between the two extremes would be optimal. This results in the need for software laboratories at CEA, ALFA and XLFA.

The agreement should establish the CEA laboratory as the central technical management point, suplemented by the LFA laboratories. Without this agreement duplication of

effort, increased development time and increased cost would occur with software ECPs.

7. UE Sets Procurement

The configuration control management plans tend to reflect the degree of complexity found in the GPS system. We feel that the selection of a 3 set UE family, with the objective of maximizing commonality in all three sets have caused the management plans undue complexity. Further research is required to support the plan of purchasing the single channel and five channel sets only. We feel that along with this research the concept of dropping the commonality objective between the two sets should also be considered. This would eliminate some of the configuration management complexity and could also free the design for more efficient operation. This would also provide the opportunity for the selection of two contractors, one for single channel and the other for the 5 channel. The overall benefits would be an increase in the technological base and production capabilities of the GPS system.

APPENDIX A

ABBREVIATIONS

1. AF Air Force
2. AFLC Air Force Logistics Command
3. AFR Air Force Regulation
4. AFSC Air Force Systems Command
5. AFSC/SD Air Force Systems Command/Space Division
6. ALC Air Logistics Center
7. ALFA Navair Lead Field Activity
8. API Airframe Platform Integration
9. APL Applied Physics Laboratory
10. C/A CODE Course/Acquistion Signal
11. CCB Configuration Control Board
12. CCBD Configuration Control Board Directive
13. CCBR Configuration Control Board Request
14. CDRL Contract Date Requirements List
15. CDU Control/Display Unit
16. CEA Central Engineering Activity
17. CI Configuration Item
18. CM Configuration Management
19. CMP Configuration Management Plan
20. CMS Configuration Management System
21. CPCI Computer Program Control Item
22. CPCSB Computer Program Configuration Sub-Board
23. CPIN Computer Program Identification Number
24. CPSP Computer Program Screening Panel
25. CRB Configurtion Review Board
26. CRISP Computer Resources Integrated Support Plan
27. CRPA Controlled Reception Pattern Antenna
28. CS Control Segment
29. CSB Configuration Sub Board

30.	CSCCB	Control Segment Configuration Control Board
31.	DMA	Defense Mapping Agency
32.	DOD	Department of Defense
33.	DSARC	Defense Systems Acquisition Review Council
34.	DT&E	Development Test and Evaluation
35.	ECP	Engineering Change Proposal
36.	ECR	Embedded Computer Resources
37.	ECS	Embedded Computer System
38.	EPROM	Electronically Progammable Read Only Memory
39.	FCA	Functional Configuration Audit
40.	FMI	Flexible Modular Interface
41.	FCC	Final Operational Configuration
42.	FRPA	Fixed Reception Pattern Antenna
43.	FSA	Field Support Activity
44.	FY	Fiscal Year
45.	GPS	Global Positioning System
46.	IAW	In Accordance With
47.	ILS	Integrated Logistic Support
48.	ILSP	Integrated Logistic Support Plan
49.	INS	Inertial Navigation System
50.	I/O	Input/Output
51.	IOT&E	Initial Operational Test and Evaluation
52.	ISF	Integration Support Facility
53.	IV&V	Independent Verification and Validation
54.	JCCB	Joint Configuration Control Board
55.	JPC	Joint Program Office
56.	JSSM	Joint Service System Manager
57.	JSSMO	Joint Service System Management Office
58.	JSSMP	Joint Service System Management Plan
59.	LBTS	Land Based Test Site
60.	LCC	Life Cycle Cost
61.	LFA	Lead Field Activity
62.	LRU	Line Replaceable Unit
63.	LSA	Logistic Support Analysis

64.	MCS	Master Control Station
65.	MIL STD	Military Standard
66.	MIS	Management Information System
67.	NAC	Naval Avionics Center
68.	NATO	North Atlantic Treaty Organization
69.	NAVAIR	Naval Air Systems Command
70.	NAVELEX	Naval Electronic Systems Command
71.	NAVSEA	Naval Sea Systems Command
72.	NCCB	Naval Configuration Control Board
73.	NESEC	Naval Electronic Systems Engineering Center
74.	OPR	Office of Primary Responsibility
75.	OSD	Office of the Secretary of Defense
76.	OT&E	Operational Test and Evaluation
77.	P Code	Precise Navigation Signal
78.	PCA	Physical Configuration Audit
79.	PCV	Physical Configuration Verification
80.	PFA	Participating Field Activity
81.	PM	Program Manager
82.	PME	Project Manager, Electronics
83.	PMR	Program Management Responsibility
84.	PMRT	Program Management Responsibility Transfer
85.	POS/NAV	Positioning and Navigation
86.	PSE	Peculiar Support Equipment
87.	PSSA	Platform System Support Activity
88.	RFI	Radio Frequency Interference
89.	RPU	Reciever Processor Unit
90.	SAC	Strategic Air Command
91.	SD	Space Division
92.	SFSA	Ships Fleet Support Activity
93.	SIA	Support Integration Activity
94.	SM	System Manager
95.	SPI	Ships Platform Integration
96.	SRU	Shop Replaceable Unit
97.	SSCCB	Space Segment Configuration Control Board

98.	SSO	System Support Office
99.	TWG	Transfer Working Group
100.	UE	User Equipment
101.	USA	United States Army
102.	USAF	United States Air Force
103.	USN	United States Navy
104.	V&V	Verificationa and Validation
105.	WR-ALC	Warner Robins Air Logistics Center
106.	XLFA	Navelex Lead Field Activity

APPENDIX B
DEFINITIONS

1. BASELINES: A configuration identification document or set of such documents (including, for example, computer program listings, tapes, card decks, etc.) formally designated and fixed at a specific time during a program's life cycle. Baselines, plus approved changes to baselines, constitue the current configuration identification. There are three distinct configuration baselines; once established, they are maintained and controlled throughout the life-cycle of the item as the following separate baselines:
   a) FUNCTIONAL BASELINE: The formally designated functional configuration identification fixed as a product of the initial or concept exploration phase of the acquisition cycle.
   b) ALLOCATED BASELINE: The formally designated allocated configuration identification fixed as a product of the demonstration and validation phase of the acquisition cycle.
   c) PRODUCT BASELINE: The formally designated product configuration identification fixed as a result of incremental completion of the configuration audits, during the full-scale development phase or as a result of the completion of the configuration audits as single events and a final product of the full-scale development phase of the acquisition cycle.
2. COMPUTER PROGRAM: A series of instructions or statements in a form acceptable to an electronic computer,

which are designed to cause the computer to execute an operation or series of operations.

3. <u>COMPUTER PROGRAM CONFIGURATION ITEM</u> (<u>CPCI</u>): A computer program that is designated by the customer for configuration management and control.
4. <u>COMPUTER PROGRAM DOCUMENTATION PACKAGE</u>: An aggregation of all program documentation that is required in the development of, or testing of, a specific computer program; i.e., flow charts, systems specifications I and II, engineering data (design test, interface specifications, etc.) source listings and source programs, programmers notebook, and like data.
5. <u>COMPUTER OPERATIONAL PROGRAMS</u>: Computer programs required to operate a system. These programs are loaded in, and run in the computer equipment during system operation; i.e., Executive/Supervisor, Functional/Application, Input/Output, and like programs.
6. <u>COMPUTER REFERENCE MANUAL</u>: Manuals related to the use of computer hardware or installation of computer hardware; i.e., manuals containing instructions or general information for the operational checkout or maintenance of computer hardware.
7. <u>COMPUTER SUPPORT PROGRAMS</u>: Computer programs generally used for the development and maintenance of other computer programs. Support programs include operating systems, assemblers, compilers, and loaders.
8. <u>COMPUTER TEST PROGRAMS</u>: Computer programs developed to analyze or test systems and component performance. These programs include maintenance and diagnostic programs to analyze performance and to detect or isolate faults in computer equipment.

9. <u>COMPUTER RESOURCES</u>: The totality of computer equipment, computer programs, associated data and documentation, related supplies, services and personnel.

10. <u>CONFIGURATION MANAGEMENT</u>: A discipline applying technical and administrative direction and surveillance to (1) identify and document the functional and physical characteristics of a configuration item, (2) control changes to those characteristics, and (3) record and report change processing and the implementation status of each change.

11. <u>CONFIGURATION STATUS ACCOUNTING</u>: The recording and reporting of an approved configuration identification, and the status of proposed changes to the approved configuration and the implementation status of approved changes.

12. <u>CONTROL SOFTWARE</u>: Common to a computer type and required to execute a computer program, but it does not contain the specific application instructions, data or logic.

13. <u>DEFICIENCY</u>:

   a) <u>Design Deficiency</u>: Any condition that limits or prevents the use of material for the purpose intended or required where the material meets all other specifications or contractual requirements. These deficiencies cannot be corrected except through a design change.

   b) <u>Quality Deficiency</u>: Any deficiency (e.g., physical, chemical, electrical, functional) noted in material which is attributable to noncomformance to applicable specifications, drawings, standards, or technical orders, or workmanship during manufacture, repair, modification, or maintenance.

c) Computer Program Deficiency: An error in the statements or instructions that make up a computer program used by an embedded computer system. The deficiency may consist of syntax, logic, or other discrepancies that cause the program to fail the intended function.

14. EMBEDDED COMPUTER SYSTEM: A computer (or computers), equipment, documentation, and programs that are integral to a weapon system, subsystem, or support system whose primary purpose is to control, sense, interpret, process, aid in, or direct operation of the larger system.

15. FIRMWARE: Software embedded in special media and cannot be readily modified under program control; that is, "read only." It can be modified only by special processes which provide physical and/or electronic access to the media. Examples are read only memory (ROM), programmable read only memory (PROM), electrically alterable read only memory (EAROM), and erasable programmable read only memory (EPROM).

16. HARDWARE INTENSIVE: Those microprocessor applications in which the function is fixed and application software/firmware is not expected to change; or would require redevelopment of the application function itself if a change is necessary.

17. INTEGRATION SUPPORT FACILITY: An engineering facility established to support weapon system embedded computer systems. It is made up of people, equipment, physical and environmental facilities, data, documentation, and procedures. Its uses may include the capability to simulate missions, evaluate computerized systems or subsystems, test modifications, and integrate hardware, software and man-machine interfaces. It provides a capability for

base line and configuration management of software configured items.

18. INTERFACE: A region common to two or more elements, systems, projects, or programs, characterized by mutual physical, functional, and/or procedural properties.
19. MICROCOMPUTER: A complete electronic computer on a single integrated circuit.
20. MICROCOMPUTER BOARD: A small number of integrated circuits on a board to form a complete electronic computer.
21. MICROCOMPUTER CHIP SET: A small number of integrated circuits that together form a complete electronic computer.
22. MICROPROGRAM FIRMWARE: Firmware at the microcode level; that is, ROM-based programs that identify the instruction set of a particular machine.
23. MICROPROCESSOR: A single integrated circuit which determines and carries out the instruction architecture of a particular computer.
24. MICROPROCESSOR FAMILY: A collection of integrated circuits which includes microprocessors and the support products necessary for carrying out a wide range of system functions.
25. ORGANIC SUPPORT: When this term is applied to weapon system computer resources, it represents the management and technical support at an AFLC family manned principally by government personnel.
26. OPERATIONAL SOFTWARE: Generally, operational software which automatically performs or assists in the performance of a navigation or weapon system mission function. Includes Built-In-Test (BIT) logic used to evaluate the status of operational equipment and/or identify faults in equipment while in an installed configuration.

27. SOFTWARE: The instructions or procedures a computer recognizes ("reads") and then executes. It is "soft" in the sense that it is easily altered. A combination of associated computer programs and computer data required to command the computer equipment to perform computational or control functions.

28. SOFTWARE INTENSIVE: Those microprocessor applications in which the function can vary and the application software/firmware is subject to change.

29. SUPPORT SOFTWARE: Programs which aid or are necessary in the preparation of computer programs such as editors, compilers, assemblers, translators, etc. which may or may not exist "on-line".

30. TEST SOFTWARE: Programs which contain the logic, stimuli identification, response evaluation, and instructions for the automatic conduct of tests. Programs used to analyze the data collected from the conduct of tests.

31. VALIDATION: As used herein, validation comprises those evaluation, integration, and test activities carried out at the system level to assure that the finally developed systems satisfies the mission requirements of the System Specification.

32. VERIFICATION: As used herein, verification is the iterative process of determining whether the product of selected steps in the CI or CPCI development process fulfills the requirements of each step, i.e., review, audit, test, etc., ascertained through an appropriate "verification method"- test, demonstration, inspection or analysis.

APPENDIX C
ECP CLASSIFICATION

Each engineering change shall be assigned the appropriate classification by the originator. Disagreements as to classification between intermediate government review activities and the originator may be appealed to the government procuring activity for decision.

CLASS I ENGINEERING CHANGE: An engineering change shall be classified Class I when one or more of the factors listed below is affected:

1. the function or allocated configuration identification
2. The product configuration identification as contractually specified, excluding referenced drawings, specifications, listing of computer program instructions and actual data values

NOTE: In the above definition of a Class I engineering change, the words "excluding referenced drawings, specifications, listing of computer program instructions, and actual data values" shall not be interpreted to exclude these items prescribed directly in a contract to define contract line items. Other drawings, specifications, computer program instructions and actual data values, whether referenced in documents or listed on associated lists are excluded from the above, but included in the below factors.

3. Technical requirements below contained in the Product Configuration Identification as contractually specified, including referenced drawings and specifications:

    a) performance outside stated tolerance

b) reliability, maintainability or survivability outside stated tolerance
c) weight, balance, moment of inertia
d) interface characteristics

4. Non-technical contractual provisions
a) fee
b) incentives
c) cost to the government
d) schedules
e) guarantees or deliveries

5. Other factors
a) government furnished equipment
b) safety
c) electromagnetic characteristics
d) operational, test or maintenance computer programs
e) compatibility with support equipment, trainers or training devices/equipment
f) configuration to the extent that retrofit action would be taken
g) delivered operation and maintenance manuals for which adequate change/revision funding is not on existing contracts
h) pre-set adjustments or schedules affecting operating limits or performance to such extent as to require assignment of a new identification number
i) interchangeability, substitutability or replaceability as applied to CI's, and to all subassemblies and parts or repairable CI's, excluding the pieces and parts of non-repairable subassemblies.
j) Sources of CI's or repairable items at any level defined by source control drawings
k) skills, manning, training, biomedical factors or human engineering design

An engineering change to a privately developed item shall be classified Class I when it affects the contractually specified form, fit or function of the item. When a greater degree of control is negotiated between the government and the contractor, effects on other factors may be added to the effects on form, fit or function factors which classify an engineering change as Class I.

CLASS II ENGINEERING CHANGE: An engineering change shall be classified class II when it does not fall within the definition of a Class I engineering change.

Examples of a Class II engineering change are:

1. a change in documentation only
2. a change in hardware which does not affect any factor listed under Class I engineering changes

APPENDIX D

CLASS I ECP JUSTIFICATION CODES

Codes corresponding with the criteria for Class I engineering changes for necessary or beneficial engineering changes are defined in the following subparagraphs. If one or more of these codes is applicable to a Class I engineering change, the one which is the most descriptive or significant shall be assigned to the ECP. If no code is pertinent, the ECP is not desired.

1. CORRECTION OF DEFICIENCY (CODE D): Code D shall be assigned to an engineering change which is required to eliminate a deficiency, unless a more descriptive separate code applies. Such separate codes are used to identify deficiencies of the nature of safety, interface or compatibility.
2. SAFETY (CODE S): Code S shall be assigned to an engineering change for correction of a deficiency which is required primarly to eliminate a hazardous condition.
3. INTERFACE (CODE B): Code B shall be assigned to an engineering change for correction of a deficiency which will eliminate interference or incompatibility at the interface between configuration items.
4. COMPATIBILITY (CODE C): Code C shall be assigned to an engineering change for correction of a deficiency of the following characteristics:
   a) The need for the change has been discovered during the system or item functional checks or during installation and checkout and is necessary to make the system or item work, and

b) The originator in assigning the compatibility code is declaring that the effort required to accomplish the change is considered to be within the scope of his existing contract, and

c) Contractual coverage completing the formal documentation of the engineering change will not reflect an increase in contract price.

5. OPERATIONAL OR LOGISTICS SUPPORT (CODE O): Code O shall be assigned to an engineering change which will make a significant effectiveness change in operational or logistics support requirements.

6. COST REDUCTION (CODE R): Code R shall be assigned to an engineering change which will provide a net total cost savings to the Government, including not only all effects on cost or price under the immediate contract but also the costs resulting from necessary associated changes in delivered items, logistic support and items produced by others.

7. VALUE ENGINEERING (CODE V): Code V shall be assigned to an engineering change which will effect a net life cycle cost reduction and which is submitted pursuant to the value engineering clause of the contract.

8. PRODUCTION STOPPAGE (CODE P): Code P shall be assigned to an engineering change which is required to prevent slippage in an approved production schedule. This code applies when production to the current configuration identification either is impracticable or can not be accomplished without delay.

9. RECORD ONLY (CODE A): Code A shall be assigned to an engineering change which, because of impact on the CI or on logistics support, is a Class I change, but owing to the contracting method, it is within the scope of the contract and should not be processed for formal change.

APPENDIX E

CLASS I ENGINEERING CHANGE PRIORITIES

A priority shall be assigned to each Class I ECP based upon a selection from the following definitions. The priority will determine the relative speed at which the ECP is reviewed and evaluated, and at which the engineering change is ordered and implemented. The proposed priority is assigned by the originator and will stand unless the procuring activity has a valid reason for changing the processing rate.

1. EMERGENCY: An emergency priority shall be assigned to an engineering change proposed for either of the following reasons:
   a) To affect a change in operational characteristics which, if not accomplished without delay, may seriously compromise the national security.
   b) To correct a hazardous condition which may result in fatal or serious injury to personnel or in extensive damage or destruction of equipment. A hazardous condition usually will require withdrawing the item from service temporarily, or suspension of the item operation, or discontinuance of further testing or development pending resolution of the condition.
2. URGENT: An urgent priority shall be assigned to an engineering change proposed for any of the following reasons:
   a) To affect a change in operational characteristics which, if not accomplished expeditiously, may seriously compromise the mission effectiveness of deployed equipment.

b) To correct a potentially hazardous condition, the uncorrected existence of which could result in injury to personnel or damage to equipment. A potentially hazardous condition compromises safety and embodies risk, but within reasonable limits, permitting continued use of the effected equipment provided the operator has been informed of the hazard and appropriate precautions have been defined and distributed to the user.

c) To meet significant contractual requirements (e.g., when lead time will necessitate slipping approved production, activation or construction schedules if the change were not incorporated).

d) To affect an interface change which, if delayed, would cause a schedule slippage or increase cost.

e) To affect, through value engineering or other cost reduction efforts, net life cycle savings to the Government of a total or more than one hundred thousand dollars, where expedited processing of the change will be a major factor in realizing these lower costs.

3. ROUTINE: A routine priority shall be assigned to a proposed engineering change when emergency or urgent is not applicable.

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Abrahamson

A critique of NAVSTAR global positioning system, user equipment, configuration control for DoD common and Navy unique items.